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Schmolz, William.

To the Editor of the

THE

Mathematical Monthly

SURVEYORS' COMPANION

with A Compliment of

R. C. Matthews

CONTAINING

A Treatise on Mathematical Instruments,

ETC. ETC.

BY

WILLIAM SCHMOLZ,

Mathematical Instrument Maker.

SAN FRANCISCO:

COMMERCIAL STEAM JOB PRESSES: VALENTINE & CO.

1859.

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THE

SURVEYOR'S AND ENGINEER'S

COMPANION:

BEING

Concise Treatise on Mathematical Instruments,

CONTAINING

AN IMPROVED METHOD OF TELESCOPIC MEASUREMENTS,

ILLUSTRATED WITH NUMEROUS ENGRAVINGS;

AND INCLUDING

THE MOST IMPORTANT AND USEFUL TABLES AND FORMULAS,

CONSTANTLY USED IN SURVEYING AND ENGINEERING.

BY

WILLIAM SCHMOLZ,

MATHEMATICAL INSTRUMENT MAKER, No. 118 MONTGOMERY STREET.

SAN FRANCISCO:
COMMERCIAL STEAM PRESSES: VALENTINE & CO.
.....
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PREFACE.

EVERY practical Surveyor must be aware that, for operations in the field, a set of Pocket Tables, of convenient size, combining the greatest accuracy with the utmost brevity, has been hitherto a desideratum. The object of the following Tables is to supply this deficiency, and it is hoped that they will answer, to some extent at least, the purpose for which they are intended. It is not expected that they are free from imperfections, or that they do not admit of improvements; but for accuracy, brevity, and perspicuity combined, it is confidently believed they are superior to any Tables, of a similar character, now extant. How far this opinion is correct must be left for others to determine.

Some of the Tables are entirely original, and others, it is supposed, are more systematically and conveniently arranged than they will be found in any other work. The Table for finding the Variation of the Magnetic Needle, at any hour of the night, and that for finding the Divergency of the Parallel of Latitude and Prime Vertical, are examples of the former, while the Table for ascertaining Altitudes by the Barometer, and that for computing the amount of Atmospheric Refraction, are examples of the latter. The first two of these Tables are not to be found in any known Treatise on Surveying, and the last two have Formulas placed at their bottom, in which every step of the calculation is clearly indicated, and the necessity of constantly referring to the Examples altogether avoided.

With the exception of the Tables for converting Sideral Time into Mean Solar Time as well as into Arc, and the reverse, which are introduced merely for facilitating the reductions, and that for finding the Hight of the Barometer corresponding to the Temperature of Boiling Water, which is acknowledged to the proper source, all the Tables in this collection have been computed anew, from the most recent authorities and the most reliable data. The Lengths of the Degrees of Latitude and Longitude are given in chains, instead of yards or feet, with the view of better adapting them to the United States system of Land Surveys.

These Tables were commenced some months since at the request of Mr. Wm. Schmolz, the publisher. They have been calculated and prepared for the press with the assistance of Messrs. W. J. Lewis and G. F. Allardt, to the former of whom, in particular, much credit is due for many valuable suggestions, and all the credit for the two last Approximate Rules given at the end of the Explanations. The calculations have been made with great care, every precaution has been taken to avoid typographical errors by comparing the revised sheets with the original computations or the best authorities, and it is firmly believed that the Rules and Tables will give results accurate to the nearest minute in angular, and to the nearest link in linear measure.

SAN FRANCISCO, JULY 6, 1859.

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CONTENTS.

	Page.
To find the Distance between two Places on the same Meridian	5
To find the Difference of Latitude between two Places on the same Meridian	5
To find the Distance between two Places on the same Parallel of Latitude	5
To find the Difference of Longitude between two Places in the same Latitude	6
To find the Convergency and Divergency of the Meridians	6
To convert Arc into Time, and Time into Arc	7
To convert Intervals of Mean Time into Sideral Time	8
To convert Intervals of Sideral Time into Mean Time	8
To find the Sideral Time corresponding to Mean Time	10
To find the Mean Time corresponding to Sideral Time	10
To find the Civil and Astronomical Time	11
To find the Mean and Sideral Time of Polaris from the Meridian	12
To find the Azimuth of Polaris	12
To find the Variation of the Needle	13
To find the Difference of Altitude by the Barometer	14
To find the Amount of Atmospheric Refraction	15
To find the Divergency of the Parallel and Perpendicular	15
To correct Random Lines	16
To run a Parallel of Latitude	16
To find the Diameter of a Tree	17
Trigonometrical Series	17
Calculation of Areas (Table A)	19
U. S. Surveys (Table B)	19

TABLES.

I.	Length of a Degree of Latitude	20
II.	Length of a Degree of Longitude	22
III.	Arc in Equivalents of Sideral Time	24
IV.	Sideral Time in Equivalents of Arc	25
V.	Mean Solar Time in Equivalent Intervals of Sideral Time	26
VI.	Sideral Time in Equivalent Intervals of Mean Solar Time	27
VII.	Azimuths of Polaris	28
VIII.	Altitudes by the Barometer	30
IX.	Altitudes by the Temperature of Boiling Water	32
X.	Atmospheric Refraction	33
XI.	Divergency of the Parallel and Prime Vertical	34
XII.	Equivalents of Linear Measures	34
XIII.	Equivalents of Superficial Measures	34

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EXPLANATION AND USE OF THE TABLES.

Tables I and II.

Table I gives the length of a degree of latitude, in chains, for every minute of latitude between 29 and 49 degrees, calculated by the Formula Dm = 5523·8724 — 27·7425 cos 2 *l* −|− ·0592 cos 4 *l*, in which *Dm* represents a degree of the meridian, and *l*, the middle latitude.

Table II gives the length of a degree of longitude, in chains, for every minute of latitude between 29 and 49 degrees, calculated by the Formula Dp = 5537·7439 cos *l* — 4·6337 cos 3 *l* −|− ·0058 cos 5 *l*, in which *Dp* represents a degree of the parallel, and *l*, the latitude.

These tables are useful for converting linear into angular, and angular into linear measure, as well as for determining the convergencies and divergencies of the meridians, on the spheroidal surface of the earth.

PROBLEMS AND EXAMPLES.

1. *Given the latitudes of any two places on the same meridian, to find the distance between them.*

RULE.—Find, from Table I, the length of a degree of the meridian at each latitude, and take half their sum for the mean length of a degree. Then say, as 60 minutes is to the difference of latitude, so is the mean length of a degree to the distance required.

The latitude of the Monte Diablo Base Line, is 37° 53′ 5″, and that of the 1st Standard North, 38° 19′ 11″; what is the meridional distance between them?

chains. chains.
As 60′ : 26′ 6″ : : 5517·205 : 2400, the distance required.

2. *Given the distance between any two places on the same meridian, and the latitude of one of them, to find their difference of latitude.*

RULE.—Find, from Table I, the length of a degree of the meridian, in the given latitude, and also in that differing from it, by the meridional distance, converted into arc at the rate of 52 seconds per mile, and take half their sum for the mean length of a degree. Then say, as the mean length of a degree is to the meridional distance, so is 60 minutes to the difference of latitude required.

The latitude of the Monte Diablo Base Line, is 37° 53′ 5″; what is the latitude of the 1st Standard North, the meridional distance being 30 miles?

chains. chains.
As 5517·205 : 2400 : : 60′ : 26′ 6″, the difference of latitude required.

3. *Given the longitudes of any two places, on the same parallel, in a given latitude, to find the distance between them.*

RULE.—Find, from Table II, the length of a degree of longitude in the

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given latitude; and say, as 60 minutes is to the difference of longitude, so is the length of the degree of longitude to the distance required.

The longitude of the Monte Diablo Meridian is 121° 54′ 1″, and that of Range 1 East, 121° 21′ 5″; what is the distance between them, on the Base Line, in latitude 37° 53′ 5″?

chains. chains.
As 60′ : 32′ 56″ : : 4372·51 : 2400, the distance required.

4. *Given the distance between any two places on the same parallel, in a given latitude, to find their difference of longitude.*

RULE.—Find from Table II, the length of degree of longitude in the given latitude; and say, as the length of the degree of longitude is to the given distance, so is 60 minutes to the difference of longitude.

The longitude of the Monte Diablo Meridian, is 121° 54′ 1″; what is the difference of longitude to Range 5 East, the distance on the Base Line, in latitude 37° 53′ 5″, being 30 miles?

chains. chains.
As 4372·51 : 2400 : : 60′ : 32′ 56″, the difference of longitude required.

5. *Given the distance between two meridians, on any parallel, in a given latitude, to find the convergency of the meridians for any distance north of that parallel.*

RULE.—Find the length of a degree of longitude, at each latitude, by the foregoing rules; and say, as the *greater* of the two lengths is to their difference, so is the given distance to the *convergency* required.

The distance between Ranges 1 and 2 on the 1st Standard North, is 6 miles, what is the convergency of the two range lines at the 2d Standard North, the meridional distance being 30 miles?

chains. chains. chains. chains.
As 4346·66 : 26·07 : : 480 : 2·88, the convergency required.

6. *Given the distance between two meridians, on any parallel, in a given latitude, to find the divergency of the meridians for any distance south of that parallel.*

RULE.—Find the length of a degree of longitude, at each latitude, by the foregoing rules; and say, as the *less* of the two lengths is to their difference, so is the given distance to the *divergency* required.

The distance between Ranges 1 and 2, on the 1st Standard South, is 6 miles; what is the divergency of the two range lines at the 2d Standard South, the meridional distance being 24 miles?

chains. chains. chains. chains.
As 4393·00 : 20·34 : : 480 : 2·22, the divergency required.

Tables III and IV.

Table III gives equivalents of degrees, minutes, and seconds of arc, in hours, minutes, and seconds of sideral time, calculated by the Formula, 360° = 24h, or 15° = 1h.

Table IV gives equivalents of hours, minutes, and seconds, of sideral time, in degrees, minutes, and seconds of arc, calculated by the Formula, 24h = 360°, or 1h = 15°.

These tables are useful in facilitating the conversion of arc into sideral time, or of sideral time into arc.

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PROBLEMS AND EXAMPLES.

1. *Given any number of degrees, minutes, and seconds of arc, to find the corresponding hours, minutes, and seconds of time.*

RULE.—Find, from Table III, the intervals of time corresponding to the degrees, minutes, and seconds, separately, and add them together; the result will be the time required.

The apparent Right Ascension of Polaris, January 1, 1860, is 16° 59′ 54″ in arc; what is it in sideral time?

1h 4m -|- 3m 56s -|- 3·60s = 1h 7m 59·60s,* the sideral time required.

The longitude of San Francisco is 122° 23′ 10″ in arc; what is it in sideral time?

8h 8m -|- 1m 32s -|- 0·67s = 8h 9m 32·67s, the sideral time required.

2. *Given any number of hours, minutes, and seconds, of time, to find the corresponding degrees, minutes, and seconds of arc.*

RULE.—Find, from Table IV, the degrees, minutes, and seconds, corresponding to the intervals of time, separately, and add them together; the result will be the arc required.

The apparent Right Ascension of Polaris, January 1, 1860, is 1h 7m 59·60s, in sideral time; what is it in arc?

15° -|- 1° 45′ -|- 14′ 45″ -|- 9″ = 16° 59′ 54″, the arc required.

The longitude of San Francisco, is 8h 9m 32·67s, in sideral time; what is it in arc?

120° -|- 2° 15′ -|- 8′ -|- 10″ = 122° 23′ 10″, the arc required.

Tables V and VI.

Table V gives mean solar time in equivalent intervals of sideral time, calculated by the Formula, 24h mean time = 24h 3m 56·555s sideral time, or 1h mean time = 1h -|- 9·8565s sideral time.

Table VI gives sideral time in equivalent intervals of mean solar time, calculated by the Formula, 24h sideral time = 23h 56m 4·091s mean time, or 1h sideral time = 1h — 9·8296s mean time.

These tables are useful, not only for converting intervals of solar into equivalent intervals of sideral time, and intervals of sideral into equivalent intervals of solar time; but also for converting any given instant of solar, to its corresponding sideral, or of sideral, to its corresponding solar time.

SIDERAL TIME AT MEAN NOON, is the angular distance of the first point of Aries from the mean Sun when on the meridian, or at mean noon; and is the time indicated by an accurate sideral clock, when the mean time clock indicates 0h 0m 0s. It *increases* 3m 56·556s † per day, and is given for every day

* The quantities throughout these examples are carried out, for exercise, to the decimal of a second, as given in the *Nautical Almanac;* but in practice, it will be unnecessary to carry them beyond the nearest minute, or the nearest second, at the utmost.

† This differs from 3m 56·555s, because it is affected by the equation of the equinoxes, and is not, *strictly*, a uniformly increasing quantity. It is the *apparent* and not the *mean* sideral time at mean noon, and should be so designated in astronomical works.

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in the year, on page II of each month, in the English *Nautical Almanac*, for the meridian of Greenwich, whence it can be calculated for any other meridian, by *adding* for the difference of longitude when *west*, or *subtracting* when *east*, 9·8565s per hour, which can be done by Table V.

MEAN TIME AT SIDERAL NOON, is the angular distance of the mean Sun from the first point of Aries when on the meridian, or at sideral noon, and is the time indicated by an accurate mean time clock, when the sideral clock indicates 0h 0m 0s. It *decreases* 3m 55·910s* per day, and is given for every day in the year, on page XX of each month, in the English *Nautical Almanac*, for the meridian of Greenwich, whence it can be calculated for any other meridian, by *subtracting* for the difference of longitude, when *west*, or *adding*, when *east*, 9·8296s per hour, which can be done by Table VI.

If the sideral time at mean noon, on any day, be subtracted from 24h, the remainder, converted into its solar equivalent, will be the mean time at sideral noon, or if the mean time at sideral noon, converted into its sideral equivalent, be subtracted from 24h, the remainder will be the sideral time, at mean noon, on the same day. In like manner, if to the sideral time on the *preceding* mean noon, at any place, be added any given interval of mean time, converted into its sideral equivalent, the result will be the corresponding sideral time; or if to the mean time, on the *preceding* sideral noon, be added any given interval of sideral time, converted into its solar equivalent, the result will be the corresponding mean time.

PROBLEMS AND EXAMPLES.

1. *Given any interval of solar time, to find its equivalent in sideral time.*

RULE.—Find, from Table V, the sideral equivalents corresponding to the given hours, minutes, and seconds, separately, and add them together; the sum will be the sideral interval required.

What is the sideral interval equivalent to 16h 12m 45·86s, mean time?

16h 2m 37·70s +| 12m 1·97s +| 45·12s +| ·87s = 16h 15m 25·66s, sid. time req'd

2. *Given any interval of sideral time, to find its equivalent in solar time.*

RULE.—Find, from Table VI, the solar equivalents corresponding to the given hours, minutes, and seconds, separately, and add them together; the sum will be the solar interval required.

What is the solar interval equivalent to 16h 15m 25·66s sideral time?

15h 57m 22·73s +| 14m 57·54s +| 24·93s +| ·66s = 16h 12m 45·86s, mean t. req

3. *Given the sideral time at mean noon, on any day, to find it on any subsequent day.*

RULE.—To the given sideral time, add 3m 56·556s for every succeeding day, diminishing the sum by 24 hours, when the former exceeds the latter, and the result will be the sideral time required.

* This differs from 3m 55·909s for the reasons given in the last note. These distinctions are of importance, because they enable us, by making a *memorandum* of the quantities, for any day of the year, to obtain them for any other day, without reference to the *Nautical Almanac*.

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The sideral time, at Greenwich mean noon, March 23, 1859, is 0h 1m 46·91s; what is it October 9, 1859?

	h.	m.	s.
Sideral time given, March 23	0	1	46·91
3m 56·556s X 200 days	13	8	31·20
Sideral time required, October 9	13	10	18·11*

The sideral time, at Greenwich mean noon, January 1, 1860, is 18h 41m 28·87s; what is it January 1, 1861?

	h.	m.	s.
Sideral time given	18	41	28·87
3m 56·556s X 366 days	24	2	59·50
Sideral time required, subtracting 24h	18	44	28·37

4. *Given the mean time at sideral noon, on any day, to find it on any subsequent day.*

RULE.—From the given mean time, subtract 3m 55·910s for every succeeding day, increasing the former by 23h 56m 4·09s, when the latter exceeds it, and the result will be the mean time required.

The mean time, at Greenwich sideral noon, March 23, 1859, is 23h 54m 17·48s; what is it October 9, 1859?

	h.	m.	s.
Mean time given, March 23	23	54	17·48
3m 55·910s X 200 days	13	6	22·00
Mean time required, October 9	10	47	55·48*

The mean time, at Greenwich sideral noon, January 1, 1860, is 5h 17m 38·95s; what is it January 1, 1861?

	h.	m.	s.
Mean time given, adding 23h 56m 4·09s	29	13	43·04
3m 55·910s X 366 days	23	59	3·06
Mean time required	5	14	39·98

5. *Given the sideral time at Greenwich, to find the corresponding sideral time at any other place.*

RULE.—*Increase* or *diminish* the given sideral time by the acceleration of sideral on solar time, taken from Table V, for the difference of longitude, according as it is *west* or *east*.

What is the sideral time, at mean noon, in San Francisco, on January 1, 1860?

	h.	m.	s.
Sideral time at Greenwich, mean noon, Jan. 1	18	41	28·87
Acceleration of sideral on solar time, for 8h 9m 33s	0	1	20·42
Sideral time required, Jan. 1	18	42	49·29

6. *Given the mean time, at Greenwich, to find the corresponding mean time at any other place.*

RULE.—*Diminish* or *increase* the given mean time by the retardation of solar on sideral time, taken from Table VI, for the difference of longitude, according as it is *west* or *east*.

What is the mean time, at sideral noon, in San Francisco, on January 1, 1860?

* Each of these quantities differs from that given in the *Nautical Almanac* only by the *hundredth* part of a second.

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	h.	m.	s.
Mean time at Greenwich, sideral noon, Jan. 1.....	5	17	38·95
Retardation of solar on sideral time, for 8h 9m 33s.....	0	1	20·20
Mean time required, Jan. 1.....	5	16	18·75

7. *Given the mean time at any place, to find the corresponding sideral time.*

RULE.—To the sideral time at the *preceding* mean noon, add the sideral equivalent of the given mean time; the sum will be the sideral time required.*

On January 1, 1860, when it is 1h 20m 30·45s mean time at San Francisco, what is the sideral time?

	h.	m.	s.
Sid. time at S. Francisco preceding mean noon, Jan. 1..	18	42	49·29
Sideral equivalent of the given mean time.....	1	20	43·68
Sideral time required, Jan. 1.....	20	3	32·97

On January 1, 1860, when it is 22h 33m 44·55s, mean time at San Francisco, what is the sideral time?

	h.	m.	s.
Sid. time at S. Francisco preceding mean noon, Jan. 1..	18	42	49·29
Sideral equivalent of given mean time.....	22	37	26·93
Sideral time required, Jan 2.....	17	20	16·22

8. *Given the sideral time at any place, to find the corresponding mean time.*

RULE.—To the mean time at the preceding sideral noon, add the solar equivalent of the given sideral time; the sum will be the solar time required.†

When it is January 1, 1860, 20h 3m 32·97s sideral time at San Francisco, what is the mean time?

	h.	m.	s.
Mean time at S. Francisco preceding sid. noon, Dec. 31..	5	20	14·66
Mean equivalent of given sideral time.....	19	59	15·79
Mean time required, Jan. 1.....	1	20	30·45

When it is January 2, 1860, 17h 20m 16·22s sideral time at San Francisco, what is the mean time?

	h.	m.	s.
Mean time at S. Francisco preceding sid. noon, Jan. 1..	5	16	18·75
Mean equivalent of given sideral time.....	17	17	25·80
Mean time required, Jan. 1.....	22	33	44·55

Table VII.

This table is useful for ascertaining the variation of the magnetic needle by the Pole Star, *at any hour of the night*, instead of waiting for the time of

* The 5th and 7th reductions may be made, at once, in *west* longitude, as follows: From the sideral interval corresponding to the sum of the longitude and the given mean time, subtract the longitude, and add the remainder to the sideral time at the *Greenwich* preceding mean noon; the result will be the sideral time at *the place of observation*.

† The 6th and 8th reductions may be made, at once, in *west* longitude, as follows: From the mean interval corresponding to the sum of the longitude and the given sideral time, subtract the longitude, and add the remainder to the mean time at the *Greenwich* preceding sideral noon; the result will be the mean time at *the place of observation*.

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greatest elongation, as must be done by the ordinary methods; and may be calculated by Spherical Trigonometry, or, more expeditiously, by the following Formulas: Let l represent the latitude of the place of observation, h the sideral hour angle of the star from its upper meridian passage, p its polar distance, and z its azimuth. Put $\sin x = \sin h \sin p$, and $\tan y = \cos h \tan p$. Then $\tan z = \tan x \sec (l \pm y)$, the positive sign being used when the star is above, and the negative when it is below the Pole.

The azimuths* of the star are given in the table, for every second degree of latitude, from 28 to 48 degrees, at variable intervals of sideral time, corresponding nearly to a uniform increase of azimuth, the successive differences being about 2 minutes, so that the intermediate minutes can be easily interpolated, and the *course* obtained *at least* with as much accuracy as it can be read, by the needle, from any portable transit instrument. The table is calculated for the mean polar distance of the star in the year 1860, and as its declination is *increasing* at the rate of about 19″ annually, the azimuths will *diminish* about 4′ in 10 years, and should, therefore, be re-calculated at intervals of about 3 years, or what would be still preferable, given annually, in some of the Nautical Almanacs.

In taking the observation, the transit must be well adjusted and properly set, with its two plates clamped together at zero; the star must then be bisected by the vertical hair of the telescope, and the *time* of observation as well as the *bearing* of the needle, *noted down*. The time should be taken by a good watch, well regulated, especially when the star is near the meridian, and converted from civil to astronomical time, the former being always reckoned 12 hours in *advance* of the latter. With these data and the Apparent Right Ascension of Polaris, or *the sideral time of its culmination*, which is given for every day in the year, on pages 366–8, of the English *Nautical Almanac*, for the meridian of Greenwich, and may be taken without any sensible error for any other meridian, the sideral time of the star from the meridian of any place can be ascertained, and the corresponding azimuth found in the table. Then the *sum* of the bearing of the needle and the azimuth of the star, when they are both east or both west, or their *difference*, when one is east and the other west, will be the variation.

PROBLEMS AND EXAMPLES.

1. *Given the civil time of day, to find the corresponding astronomical time.*

RULE.—In the forenoon of the civil day, increase the hour of the day by 12 and diminish the day of the month by unity; in the afternoon the hour of the day and the day of the month are the same as in the civil reckoning.

When it is 35m past 3 o'clock A. M. January 2, civil time, what is the astronomical time?

	d.	h.	m.
Civil time	Jan. 2	3	35
Correction	— 1	+12	
Astronomical time required	Jan. 1	15	35

* The azimuth at the time of greatest elongation, is found by the proportion: As cos latitude : radius : : sin polar distance : sin azimuth; and does not differ, sensibly, in any of the latitudes in the table, from the azimuth at 6 sideral hours from the meridian.

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2. *Given the astronomical time of day, to find the corresponding civil time.*

RULE.—In the last 12 hours of the astronomical day, diminish the hour of the day by 12 and increase the day of the month by unity; in the first 12 hours, the hour of the day and day of the month are the same as in the astronomical reckoning.

When it is 15h 35m on January 1, astronomical time, what is the civil time?

	d.	h.	m.
Astronomical time	Jan. 1	15	35
Correction	+1	−12	
Civil time	2	3	35

3. *Given the sideral time of day, to find the mean time of Polaris from the meridian.*

RULE.—To the mean time at sideral noon, on the given day, add the mean interval corresponding to the sum of the given sideral time and the Right Ascension of the star.

What is the mean time of the upper transit of Polaris, at San Francisco, January 1, 1860?

	h.	m.	s.
Mean time at sideral noon, Jan. 1	5	16	18·75
Mean equivalent of S. T. + R. A.*	1	7	48·49
Mean time of transit required	6	24	7·24

What is the mean time of the lower transit of Polaris, at San Francisco, January 1, 1860?

	h.	m.	s.
Mean time at sideral noon, Jan. 1	5	16	18·75
Mean equivalent of S. T. + R. A.	13	5	50·54
Mean time of transit required	18	22	9·29

4. *Given the mean time of day, to find the sideral time of Polaris from the meridian.**

RULE.—To the sideral time at mean noon, on the given day, add the sideral interval corresponding to the given mean time, diminished by the Right Ascension of the star; and the result will be the sideral time required.

What is the sideral time of Polaris from the meridian of San Francisco, January 1, 1860, at 9h 45m 15s, A. M. civil time?

	h.	m.	s.
Sideral time at mean noon, Dec. 31	18	38	52·73
Sideral equivalent of M. T. — R. A.	20	40	49·96
Sideral time required	15	19	42·69

What is the sideral time of Polaris from the meridian of San Francisco, January 1, 1860, at 9h 30m 30s P. M. civil time?

	h.	m.	s.
Sideral time at mean noon, Jan. 1	18	42	49·29
Sideral equivalent of M. T. — R. A.	8	24	4·66
Sideral time required	3	6	53·95

* The sideral time from the meridian at the greatest elongation, is found by the proportion: As radius : tangent latitude : : tangent polar distance : cosine hour angle, and is, in this latitude, about 4 minutes less than 6 sideral hours.

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5. Given the mean time of observation and the bearing of the needle, to find the variation.

RULE.—Find in one of the right or left hand columns of the table, the sidereal time of the star from the meridian at the mean time of observation, and opposite to it, under the latitude of the place, will be found the azimuth, east or west, as indicated at the head of the column; then the *sum* of the bearing of the needle and the azimuth, when they are both east or both west, or their *difference*, when one is east and the other west, will be the variation.

At San Francisco on May 7, 1859, at 9h 16m P. M., the bearing of the needle was N. 16° 15′ E. when the vertical hair of the transit instrument was on the North Star. Required the variation.

	h.	m.	s.
Sideral time at mean noon	2	59	12
Sideral equivalent of M. T. — R. A.	8	9	48
Sideral time of star from meridian	11	9	0
Bearing of the needle	N. 16°	15′	E.
Azimuth from table		24	W.
Variation	15	51	E.

If the mean, instead of the apparent Right Ascension of Polaris,* converted once for all, from sideral into its equivalent interval in solar time, be used, and a *memorandum* of it taken, the *Nautical Almanac* may be dispensed with altogether in the field, and the operation somewhat simplified by adopting the following:

RULE.—Increase the time of day, shown by the watch, commencing, successively, at 4, 10, 16, and 22 hours, by 1, 2, 3, or 4 minutes, respectively; from this subtract the mean time at the preceding sideral noon, and the mean equivalent of the Right Ascension, and opposite to the remainder the azimuth will be found in the table.

Tables VIII and IX.

Table VIII is used for determining the difference of altitude between any two places, by means of the barometer, and is calculated by the Formula of La Place, as modified by later writers, in accordance with the results of more accurate observations. The original Formula, with the view of simplifying the operation, is separated into four distinct parts, which are given in so many simple Formulas at the bottom of the table. The successive steps of the computation, are as follows:

* The mean Right Ascension of Polaris, for the year 1860, is 1h 8m 2·61s, the mean solar equivalent of which is 1h 7m 51·46s, or 1h 8m, taking it to the nearest minute. It increases at the rate of about 19s annually, or a little less than a minute in three years. The apparent Right Ascension diminishes, annually, from the 1st of the year until about the 3d of April, when it becomes a minimum; it then increases until about the 18th of October, when it becomes a maximum; and then diminishes until the end of the year. It never varies from the mean Right Ascension more than about one minute, a quantity which can hardly affect the accuracy of any bearing taken by the magnetic needle.

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1. Observe the hights H and H′ of the barometers at the lower and upper stations, find the numbers N and N′ corresponding to them, from the first page of the table, subtract the latter from the former, and the difference will be the first approximate altitude, D.

2. Observe the hights T and T′ of the attached thermometers * at the lower and upper stations, subtract the latter from the former, multiply the difference by 2·3409, and *diminish* or *increase* the approximate altitude D by the product, according as it is *positive* or *negative*; † the result will be the second approximate altitude, C.

3. Observe the hights t and t′ of the detached thermometers at the lower and upper stations, subtract 64° from their sum, multiply the difference by the nine hundredth part of C, and *increase* or *diminish* the approximate altitude C by the product, according as it is *positive* or *negative*; the result will be the third approximate altitude, B.

4. Opposite the approximate altitude B, in the right or left hand column of the last page of the table, and respectively, under the latitude, elevation, and hight of the barometer at the lower station, find the numbers L, E, and S; add E and S to the approximate altitude B, and *increase* or *diminish* the sum by L, according as the latitude is *less* or *greater* than 45°; and the result will be the true difference of altitude between the two stations.

EXAMPLES.

Find the altitude of the mountain of Guanaxuato, in Mexico, in latitude 21° N, from the following observations made by Baron Humboldt:

	L. Sta. on bank of sea.	U. Sta. on Guanaxuato.
Barometer	H = 30·046 inches	H′ = 23·660 inches.
Attached thermometer	T = 77·5°	T′ = 70·3°
Detached thermometer	t = 77·5°	t′ = 70·3°

Formula 1 gives for H = 30·046 inches ..... N = 27649·7 feet.
" " H′ = 23·660 " ..... N′ = 21406·9 "

First approximate altitude ..... 6242·8 "

Formula 2 gives 2·3409 (77·5 — 70·3) = 2·3409 × 7·2 ... = — 16·9 "

Second approximate altitude ..... 6225·9 "

Form. 3 gives $\frac{6225·9}{900}$ (77·5 + 70·3 — 64) = 6·918 × 83·8 = + 579·7 "

Third approximate altitude ..... 6805·6 "

Formula 4 gives 13·3 + 19·3 + 0 ..... = 32·6 "

True altitude required ..... 6838·2 "

When Gay Lussac made his celebrated balloon ascent in 1805, the following observations were made, from which it is required to find the elevation of the balloon above Paris in latitude 49°.

	L. Sta. at Paris.	U. Sta. at baloon.
Barometer	H = 30·145 inches	H′ = 12·945 inches.
Attached thermometer	T = 87·44°	T′ = 14·9°
Detached thermometer	t = 87·4₂°	t′ = 14·9°

* The thermometer referred to, in every instance, in these tables, is Fahrenheit's.

† This correction is generally negative, because the temperature at the lower generally exceeds that at the upper station.

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Formula 1 gives for H = 30·145 inches.....	N = 27735·6 feet.	
" " H′ = 12·945 "	N′ = 5650·4 "	
First approximate altitude.....	22085·2 "	
Form. 2 gives 2·3409 (87·44 — 14·9) = 2·3409 X 72·54.. =	— 169·9 "	
Second approximate altitude.....	21915·3 "	
Fm. 3 gives $\frac{21915·3}{900}$ (87·44 + 14·9—64)=24·35 X 38·34 =	+ 933·6 "	
Third approximate altitude.....	22848·9 "	
Formula 4 gives — 8·2 + 82·1 + 0..... =	+ 73·9 "	
Elevation required.....	22922·8 "	

Table IX is designed for dispensing with the barometer, in the observations necessary for determining the altitude from the foregoing table, by substituting the temperature of boiling water in its place, and is copied from the recent admirable Treatise on Practical Astronomy, by Professor Loomis.

Table X.

This table is used in ascertaining the amount of atmospheric refraction, for all altitudes, from the horizon to the zenith, according to Bessel's Formula, which is considered more accurate than any other. The requisite data are the apparent altitude and the hight of the barometer as well as that of the attached and detached thermometers, at the time of observation, from which the true refraction is obtained as follows:

Find, from the table, the mean refraction corresponding to the apparent altitude; the factor B, corresponding to the hight of the barometer; and the factors T and T′, corresponding to the hights of the attached and detached thermometers, respectively. Multiply these four numbers together, and the product will be the true refraction.

EXAMPLES.

Near Oroville, Dec. 26, 1857, the apparent meridian altitude of Polaris was observed to be 41° 1′ 40″, the barometer indicating 29·8 inches, the attached thermometer, 46°, and the detached thermometer, 44°; what is the refraction?

The table gives M X B X T X T′ = 66·236″ X 1·007 X ·999 X 1·009 = 67·23″ = 1′ 7·2″, the refraction.

The observed apparent altitude of a star was 3° 44′ 40″, the barometer indicated 30·162 inches, the attached and detached thermometers, 52·2° and 46·6°, respectively. Required the refraction.

The table gives M X B X T X T′ = 732·967″ X 1·019 X ·998 X 1·004 = 748·36″ = 12′ 28·4″, the refraction.

Table XI.

This table gives the divergency of the Parallel of Latitude from the Prime Vertical,* or perpendicular to the meridian, on the spheroidal surface of the

* The length of a degree of the Prime Vertical may be calculated by the Formula $Dv = 5551·6748 - 18·6536 \cos^2 l + ·0940 \cos^4 l$; in which *Dv* represents a degree of the Prime Vertical, in chains, and *l* the latitude.

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earth, at every second degree of latitude, from 28 to 48 degrees, for any number of miles from 1 to 36; and is useful in running a parallel of latitude by fore and back sighting.

EXAMPLE.

If a line commenced on the parallel of 37° north latitude, be extended east or west, 27½ miles, by fore and back sighting, what distance will its terminus be south of that parallel?

	chains.
The table gives for 27 miles in latitude 37°..	5·52
" " 28 " " ..	5·94
The mean of which is.....	5·73 the dist'ce required.

Tables XII and XIII.

These tables show the relations of different standard lineal and superficial measures, and are useful in facilitating the reductions from one denomination to another. They are familiar to every person and require no explanation.

APPROXIMATE RULES CONVENIENT IN PRACTICE.

I. For Correcting Random Lines.*

1. *Given the error of latitude or departure for any distance, to find the error of the course.*

Rule.—Three-sevenths of the error of latitude or departure, *per mile*, in *links*, will be the error of the course, in *minutes*.

EXAMPLE.

What is the error of the course for an error of 210 links of latitude or departure, in 6 miles?

Here the error, per mile, is 35 links, three-sevenths of which is 15′, the error required.

2. *Given the error of the course, to find the corresponding error of latitude or departure for any distance.*

Rule.—Seven-thirds of the error of the course, in *minutes*, will be the error of latitude or departure, *per mile*, in *links*.

EXAMPLE.

What is the error of latitude or departure, in 6 miles, for an error of 15′ in the course?

Here seven-thirds of 15 is 35 links, the error per mile, or 210 links in 6 miles, the error required.

II. For Running a Parallel of Latitude.†

Given the distance run, east or west, on a great circle, to find the divergency from the parallel of latitude.

Rule.—Multiply the square of the distance in *miles*, by the natural tangent of the latitude, and the product will be the divergency, in *links*.

* This approximation is true to the *nearest minute* for all angles up to 3°; and to the *nearest quarter of a degree* for all angles up to 11¼°.

† This approximation may be considered practically correct for any distance not exceeding 30 miles.

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EXAMPLE.

After running 6 miles, east or west, on the arc of a great circle, from latitude 38°, what will be the meridional distance south of the parallel?

Here we have $\cdot 781 \times 6^2 = 28$ links, the divergency required.

III. FOR FINDING THE DIAMETER OF A TREE.

RULE.—Annex a cipher to the number of *links* around the tree, and one-fourth of the result will be the diameter, in *inches*.

EXAMPLE.

What is the diameter of a tree whose circumference is 16 links?

Here we have $\frac{1}{4}$ of 160 = 40 inches, the diameter required.

TRIGONOMETRICAL SERIES.

$$\text{Sin } A = A - \frac{A^3}{2\cdot3} + \frac{A^5}{2\,3\cdot4\cdot5} - \frac{A^7}{2\cdot3\cdot4\cdot5\cdot6\cdot7} + \text{etc.}$$

$$\text{Cos } A = 1 - \frac{A^2}{2} + \frac{A^4}{2\cdot3\cdot4} - \frac{A^6}{2\cdot3\cdot4\cdot5\cdot6} + \text{etc.}$$

$$\text{Tan } A = A + \frac{A^3}{3} + \frac{2A^5}{3\cdot5} + \frac{17A^7}{3^2\cdot5\cdot7} + \text{etc.}$$

$$\text{Cot } A = \frac{1}{A} - \frac{A}{3} - \frac{A^3}{3^2\cdot5} - \frac{2A^5}{3^3\,5\cdot7} - \text{etc.}$$

$$\text{Arc } A = \sin A + \frac{\sin^3 A}{2\cdot3} + \frac{3\sin^5 A}{2\cdot4\cdot5} + \frac{3\cdot5\sin^7 A}{2\cdot4\cdot6\cdot7} + \text{etc.}$$

$$\text{Arc } A = \tan A - \frac{1}{3}\tan^3 A + \frac{1}{5}\tan^5 A - \frac{1}{7}\tan^7 A + \text{etc.}$$

Tables A and B.

Table A is an improved method of tabling the computation of areas. It requires 16 columns of the proper width, the first nine of which contain the numbers, courses, distances, northings, southings, eastings, westings, latitude corrections, and departure corrections, in the same order as the usual method. The 10th and 13th columns contain the corrected departures and corrected latitudes, with their proper *signs*, that is, the eastings and westings, as well as the northings and southings, must have *contrary* signs, it being wholly immaterial which of the courses are marked *positive*, provided those running in an *opposite* direction are marked *negative*. The 11th and 12th columns contain the departure ordinates and latitude ordinates, or the rectangular distances of each successive station from the meridian and parallel passing through the initial point of the survey. The 14th column contains the double meridian distances, or the sums of the two rectangular distances of the extremities of each successive course from the meridian passing through the origin. The 15th and 16th columns contain the + areas and — areas, or the double areas of the successive trapeziums into which the tract is divided, which are bounded, respectively, by the principal meridian, the successive courses, and their corresponding departure ordinates.

The numbers, courses, and distances, are marked, run, and measured in the

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field. The northings, southings, eastings, and westings, are obtained from the courses and distances, by the Traverse Table. The latitude and departure corrections, are obtained by distributing the errors in latitude and departure, in proportion to the corresponding distances, or in any other proportion which will be more likely to insure greater accuracy. The corrected departures and latitudes are obtained from the northings, southings, eastings, and westings, by the proper application of their respective corrections. The first departure ordinate and latitude ordinate are the same as their corresponding departure and latitude, and each succeeding ordinate is found from that immediately preceding it, by *adding* or *subtracting* its corresponding departure or latitude, according as the signs are *alike* or *unlike*. The first double meridian distance is the same as its corresponding departure ordinate, and each succeeding double meridian distance is found from the preceding departure ordinate by *adding* or *subtracting* its corresponding departure ordinate, according as the signs are *alike* or *unlike*. The areas are obtained by multiplying each double meridian distance by its corresponding latitude and are $+$ or $-$, according as the signs are *alike* or *unlike*. Finally, the area of the survey is obtained by taking half the difference of the total positive and negative areas.

The advantages of this method are obvious. The columns which are constantly used together, or of which one is derived from the other, are, for convenience of reference as well as calculation, placed in juxtaposition. For instance, the departure and latitude ordinates, from which the survey is plotted are placed along side each other, while they are, at the same time, along side their corresponding departures and latitudes, from which they are deduced. In the same manner, the double meridian distances and their corresponding latitudes, from which the areas are computed, are also placed along side each other, and the confusion incident to looking continually from one side of the page to the other, is thus avoided. The tabling may be commenced from any station of the survey, at pleasure, if the courses are taken around, in regular succession, to the place of beginning.

The following tests of the accuracy of the calculations are very important, and a knowledge of them may save considerable time and trouble. The difference between the sum of the eastings and that of the westings, at every step of the calculation, must differ from the corresponding departure ordinate by the amount of the departure corrections, up to that point. In like manner, the difference between the sum of the northings and that of the southings, at every stage of the computation, must differ from the corresponding latitude ordinate, by the amount of the latitude corrections up to that point. The total amount of the latitude and departure corrections must be respectively equal to the errors in latitude and departure, and each of the last ordinates must always be *nothing*. The only portions of the work which do not check themselves, are the double meridian distances* and the areas, and these should, therefore, be reviewed; or, which would be preferable, calculated separately, by two persons.

Table B shows the relative positions of the principal lines of the United States Surveys, in California, and is useful for obtaining, approximately, the latitudes and longitudes of places in their vicinity.

* The algebraic sum of the double meridian distances must always be twice that of the departure ordinates.

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A. *Tabling of the Survey of the Rancho "Cañada de Herrera," situated in Marin County, California.*

No.	Course.	Dist.	N.	S.	E.	W.	L. C.	D. C.	Dep.	D. O.	L. O.	Lat.	D. M. D.	-/- Area.	— Area.
1	N 11¼ E	78·90	77·38	..	15·40	..	23	11	— 15·51	— 15·51	77·15	77·15	— 15·51		1196·5965
2	N 33 W	110·00	92·26	..	..	59·91	32	15	59·76	44·25	169·09	91·94	28·74	2642·3556	...
3	N 47¼ W	155·40	105·48	..	..	114·11	46	21	113·90	158·15	274·11	105·02	202·40	21456·0480	...
4	S 64 W	75·20	..	32·97	..	67·59	22	10	67·49	225·64	240·92	— 33·19	343·79	...	12737·9901
5	S 5 W	9·00	..	8·97	..	0·78	3	1	0·77	226·41	231·92	— 9·00	452·05	...	4068·4500
6	S 56¼ W	27·90	..	15·40	..	23·26	8	4	23·22	249·63	216·44	— 15·48	476·04	...	7369·0992
7	S 9 W	41·60	..	41·09	..	6·50	12	6	6·44	256·07	175·23	— 41·21	505·70	...	20839·8870
8	S 45½ W	49·50	..	34·69	..	35·31	14	7	35·24	291·31	140·40	— 34·85	547·38	...	19065·2454
9	S 10½ W	53·10	..	52·25	..	9·45	16	7	9·38	300·69	87·99	— 52·41	592·00	...	31026·7200
10	S 14 E	124·60	..	120·90	30·15	..	37	17	— 30·32	270·37	— 33·28	—121·27	571·06	...	69252·4462
11	N 83¼ E	239·70	28·16	..	238·05	..	70	33	—238·38	31·99	— 5·82	27·46	302·36	8302·8056	...
12	N 79½ E	32·50	5·92	..	31·95	..	10	4	— 31·99	0·00	0·00	5·82	31·99	186·1818	...
		997·40	309·20 306·27	306·27	315·55	316·91 315·55	293	136						32387·3910	165556·4444 32387·3910
			2·93			1·36									20) 133169·0534
						Area, 6658·45 acres.									6658·45267

B. *Position of the Principal Lines of the United States Surveys in the State of California.*

Surveys North of the Monte Diablo Base Line.

Parallel.	Latitude.			Dist.	Lon. pr.			R'nge			Conver.
	°	′	″	miles.	°	′	″				chains.
Monte Diablo Base Line....	37	53	5	0	0	6	35·2	0	0	0	0·00
I Standard North.....	38	19	11	30	0	6	37·5	0	2	8	2·84
II " "	38	45	16	60	0	6	39·9	0	2	8	2·88
III " "	39	11	22	90	0	6	42·4	0	2	9	2·93
IV " "	39	37	28	120	0	6	44·9	0	2	9	2·97
V " "	40	3	33	150	0	6	47·5	0	3	0	3·02
VI " "	40	29	39	180	0	6	50·1	0	3	0	3·06
VII " "	40	55	44	210	0	6	52·8	0	3	1	3·11
VIII " "	41	21	49	240	0	6	55·5	0	3	1	3·16
IX " "	41	47	54	270	0	6	58·3	0	3	2	3·21
Oregon Boundary.....	42	0	0	284	0	6	59·6	0	1	5	1·51

Surveys South of the Monte Diablo Base Line.

Parallel.	Latitude.			Dist.	Lon. pr.			R'nge			Diverg.
	°	′	″	miles.	°	′	″				chains.
Monte Diablo Base Line....	37	53	5	0	0	6	35·2	0	0	0	0·00
I Standard South.....	37	32	12	24	0	6	33·4	0	2	2	2·25
II " "	37	11	19	48	0	6	31·6	0	2	2	2·22
III " "	36	50	26	72	0	6	29·8	0	2	1	2·19
IV " "	36	29	32	96	0	6	28·0	0	2	1	2·17
V " "	36	8	39	120	0	6	26·3	0	2	1	2·14
VI " "	35	47	46	144	0	6	24·6	0	2	1	2·11
VII " "	35	26	53	168	0	6	22·9	0	2	0	2·09
VIII " "	35	5	59	192	0	6	21·3	0	2	0	2·06
IX " "	34	45	6	216	0	6	19·7	0	2	0	2·03
X " "	34	24	13	240	0	6	18·1	0	2	0	2·00

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Length of a Degree of Latitude.

′	29°	30°	31°	32°	33°	34°	35°	36°	37°	38°	′
	chains.	chains.	chains.	chains.	chains.	chains.	chains.	chains.	chains.	chains.	
0	5509·15	5509·93	5510·82	5511·67	5512·55	5513·44	5514·34	5515·25	5516·18	5517·11	0
1	09·16	09·99	10·83	11·69	12·56	13·45	14·35	15·27	16·19	17·13	1
2	09·17	10·00	10·84	11·70	12·58	13·47	14·37	15·28	16·21	17·14	2
3	09·19	10·01	10·86	11·72	12·59	13·48	14·38	15·30	16·22	17·16	3
4	09·20	10·03	10·87	11·73	12·61	13·50	14·40	15·31	16·24	17·17	4
5	09·21	10·04	10·89	11·75	12·62	13·51	14·42	15·33	16·25	17·19	5
6	09·23	10·06	10·90	11·76	12·64	13·53	14·43	15·34	16·27	17·20	6
7	09·24	10·07	10·91	11·78	12·65	13·54	14·45	15·36	16·28	17·22	7
8	09·25	10·08	10·93	11·79	12·67	13·56	14·46	15·38	16·30	17·23	8
9	09·27	10·10	10·94	11·81	12·68	13·57	14·48	15·39	16·32	17·25	9
10	09·28	10·11	10·96	11·82	12·70	13·59	14·49	15·41	16·33	17·27	10
11	09·30	10·13	10·97	11·83	12·71	13·60	14·51	15·42	16·35	17·28	11
12	09·31	10·14	10·99	11·85	12·73	13·62	14·52	15·44	16·36	17·30	12
13	09·32	10·15	11·00	11·86	12·74	13·63	14·54	15·45	16·38	17·31	13
14	09·34	10·17	11·01	11·88	12·76	13·65	14·55	15·47	16·39	17·33	14
15	09·35	10·18	11·03	11·89	12·77	13·66	14·57	15·48	16·41	17·34	15
16	09·36	10·19	11·04	11·91	12·79	13·68	14·58	15·50	16·42	17·36	16
17	09·38	10·21	11·06	11·92	12·80	13·69	14·60	15·51	16·44	17·38	17
18	09·39	10·22	11 07	11·94	12·81	13·71	14·61	15·53	16·46	17·39	18
19	09·41	10·24	11·09	11·95	12·83	13·72	14·63	15·54	16·47	17·41	19
20	09·42	10·25	11·10	11·96	12·84	13·74	14·64	15·56	16·49	17·42	20
21	09·43	10·26	11·11	11·98	12·86	13·75	14·66	15·57	16·50	17·44	21
22	09·45	10·28	11·13	11·99	12·87	13·77	14·67	15·59	16·52	17·45	22
23	09·46	10·29	11·14	12·01	12·89	13·78	14·69	15·61	16·53	17·47	23
24	09·47	10·31	11·16	12·02	12·90	13·80	14·70	15·62	16·55	17·49	24
25	09·49	10 32	11·17	12·04	12·92	13·81	14·72	15·64	16·56	17·50	25
26	09·50	10·33	11·19	12·05	12·93	13·83	14·73	15·65	16·58	17·52	26
27	09·51	10·35	11·20	12·07	12·95	13·84	14·75	15·67	16·60	17·53	27
28	09·53	10·36	11·21	12·08	12·96	13·86	14·76	15·68	16·61	17·55	28
29	09·54	10·38	11·23	12·10	12·98	13·87	14·78	15·70	16·63	17·56	29
30	09·56	10·39	11·24	12·11	12·99	13·89	14·79	15·71	16·64	17·58	30
31	09·57	10·41	11·26	12·12	13·01	13·90	14·81	15·73	16·66	17·60	31
32	09·58	10·42	11·27	12·14	13·02	13·92	14·82	15·74	16·67	17·61	32
33	09·60	10·44	11·29	12·15	13·04	13·93	14·84	15·76	16·69	17·63	33
34	09·61	10 45	11·30	12·17	13·05	13·95	14·86	15·77	16·70	17·64	34
35	09·63	10·46	11·31	12·18	13·07	13·96	14·87	15·79	16·72	17·66	35
36	09·64	10·48	11·33	12·20	13·08	13·98	14·89	15·81	16·74	17·67	36
37	09·65	10·49	11·34	12·21	13·10	13·99	14·90	15·82	16·75	17·69	37
38	09·67	10·50	11·36	12·22	13·11	14·01	14·92	15·84	16·77	17·71	38
39	09·68	10·52	11·37	12·24	13·13	14·02	14·93	15·85	16·78	17·72	39
40	09·69	10·53	11·39	12·26	13·14	14·04	14·95	15·87	16·80	17·74	40
41	09·71	10·55	11·40	12·27	13·16	14·05	14·96	15·88	16·81	17·75	41
42	09·72	10·56	11·42	12·29	13·17	14·07	14·98	15·90	16·83	17·77	42
43	09·74	10·57	11·43	12·30	13·18	14·08	14·99	15·91	16·84	17·78	43
44	09·75	10·59	11·44	12·31	13·20	14·10	15·01	15·93	16·86	17·80	44
45	09·76	10·60	11·46	12·33	13·21	14·11	15·02	15·94	16·88	17·82	45
46	09·78	10·62	11·47	12·34	13·23	14·13	15·04	15·96	16·89	17·83	46
47	09·79	10·63	11·49	12·36	13·24	14·14	15·05	15·98	16·91	17·85	47
48	09·80	10·65	11·50	12·37	13·26	14·16	15·07	15·99	16·92	17·86	48
49	09·82	10·66	11·52	12·39	13·27	14 17	15·08	16·01	16·94	17·88	49
50	09·83	10·67	11·53	12·40	13·29	14·19	15·10	16·02	16·95	17·89	50
51	09·85	10·69	11·54	12·42	13·30	14·20	15·11	16·04	16·97	17·91	51
52	09·86	10·70	11·56	12·43	13·32	14·22	15·13	16·05	16·98	17·93	52
53	09·87	10·72	11·57	12·45	13·33	14·23	15·15	16·07	17·00	17·94	53
54	09·89	10·73	11·59	12·46	13·35	14·25	15·16	16·08	17·02	17·96	54
55	09·90	10·74	11·60	12·48	13·36	14·26	15·18	16·10	17·03	17·97	55
56	09·92	10·76	11·62	12·49	13·38	14·28	15·19	16·11	17·05	17·99	56
57	09·93	10·77	11·63	12·51	13·39	14·29	15·21	16·13	17·06	18 00	57
58	09·94	10·79	11·65	12·52	13·41	14·31	15·22	16 15	17·08	18·02	58
59	09·96	10·80	11·66	12·53	13 42	14·32	15·24	16·16	17·09	18·04	59
60	09·97	10·82	11·67	12·55	13·44	14·34	15·25	16·18	17·11	18·05	60

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Length of a Degree of Latitude.

′	39°	40°	41°	42°	43°	44°	45°	46°	47°	48°	′
	chains.	chains.	chains.	chains.	chains.	chains.	chains.	chains.	chains.	chains.	
0	5518·05	5519·00	5519·96	5520·92	5521·88	5522·85	5523·81	5524·78	5525·75	5526·72	0
1	18·07	19·02	19·97	20·93	21·90	22·86	23·83	24·80	25·77	26·73	1
2	18·08	19·03	19·99	20·95	21·91	22·88	23·85	24·82	25·78	26·75	2
3	18·10	19·05	20 00	20·96	21·93	22·89	23·86	24·83	25·80	26·76	3
4	18·11	19·06	20·02	20·98	21·94	22·91	23·88	24·85	25·82	26·78	4
5	18·13	19·08	20·04	21·00	21·96	22·93	23·90	24·86	25 83	26·80	5
6	18·15	19·10	20·05	21·01	21·98	22·94	23·91	24·88	25·85	26·81	6
7	18·16	19·11	20·07	21·03	21·99	22·96	23·93	24·90	25·86	26·83	7
8	18·18	19·13	20·08	21·04	22·01	22·98	23·94	24·91	25·88	26·84	8
9	18·19	19·14	20·10	21·06	22·02	22·99	23·96	24·93	25·90	26·86	9
10	18·21	19·16	20·12	21·08	22·04	23·01	23·98	24·94	25·91	26·88	10
11	18·22	19·18	20·13	21·09	22·06	23·02	23·99	24·96	25·93	26·89	11
12	18·24	19·19	20·15	21·11	22·07	23·04	24·01	24·98	25·94	26·91	12
13	18·26	19 21	20·16	21·12	22·09	23·06	24·02	24·99	25·96	26·92	13
14	18·27	19·22	20·18	21·14	22·11	23·07	24·04	25·01	25·98	26·94	14
15	18·29	19·24	20·20	21·16	22·12	23·09	24·06	25·03	25·99	26·96	15
16	18·30	19·25	20·21	21·17	22·14	23·10	24·07	25·04	26·01	26·97	16
17	18·32	19·27	20·23	21·19	22·15	23·12	24·09	25·06	26·02	26·99	17
18	18·34	19·29	20·24	21·20	22·17	23·14	24·11	25·07	26·04	27·00	18
19	18·35	19·30	20·26	21·22	22·19	23·15	24·12	25·09	26·06	27·02	19
20	18·37	19·32	20·28	21·24	22·20	23·17	24·14	25·11	26·07	27·04	20
21	18·38	19·33	20·29	21·25	22·22	23·19	24·15	25·12	26·09	27·05	21
22	18·40	19·35	20·31	21·27	22·23	23·20	24·17	25·14	26·10	27·07	22
23	18·41	19·37	20·32	21·29	22·25	23·22	24·19	25·15	26·12	27·09	23
24	18·43	19·38	20·34	21·30	22·27	23·23	24·20	25·17	26·14	27·10	24
25	18·45	19·40	20·36	21·32	22·28	23·25	24·22	25·19	26·15	27·12	25
26	18·46	19·41	20·37	21·33	22·30	23·27	24·23	25·20	26·17	27·13	26
27	18·48	19·43	20·39	21·35	22·31	23 28	24·25	25·22	26·19	27·15	27
28	18·49	19·45	20·40	21·36	22·33	23·30	24·27	25·23	26·20	27·17	28
29	18·51	19·46	20·42	21·38	22·35	23·31	24·28	25·25	26·22	27·18	29
30	18·53	19·48	20·44	21·40	22·36	23·33	24·30	25 27	26·23	27·20	30
31	18·54	19·49	20·45	21·41	22·38	23·35	24·32	25·28	26·25	27·21	31
32	18·56	19 51	20·47	21·43	22·40	23·36	24·33	25·30	26·27	27·23	32
33	18·57	19·53	20·48	21·45	22·41	23·38	24·35	25·32	26·28	27·25	33
34	18 59	19·54	20·50	21·46	22·43	23·40	24·36	25·33	26·30	27·26	34
35	18·60	19·56	20·52	21·48	22·44	23·41	24·38	25·35	26·31	27·28	35
36	18·62	19·57	20·53	21·49	22·46	23·43	24·40	25·36	26·33	27·29	36
37	18·64	19·59	20·55	21·51	22·48	23·44	24·41	25·38	26·35	27·31	37
38	18·65	19·60	20·56	21·53	22·49	23·46	24·43	25·40	26·36	27·33	38
39	18·67	19·62	20 58	21·54	22·51	23·48	24·44	25·41	26·38	27·34	39
40	18·68	19·64	20·60	21·56	22·52	23·49	24·46	25·43	26·39	27·36	40
41	18·70	19·65	20·61	21·57	22·54	23·51	24·48	25·44	26·41	27·37	41
42	18·72	19·67	20·63	21·59	22·56	23·52	24·49	25·46	26·43	27·39	42
43	18·73	19·68	20·64	21·61	22·57	23·54	24·51	25·48	26·44	27·41	43
44	18 75	19·70	20·66	21·62	22·59	23·56	24·52	25·49	26·46	27·42	44
45	18·76	19·72	20·68	21·64	22·60	23·57	24·54	25·51	26·47	27·44	45
46	18·78	19·73	20·69	21·65	22·62	23·59	24·56	25·52	26·49	27·45	46
47	18·79	19·75	20·71	21·67	22·64	23·60	24·57	25·54	26·51	27·47	47
48	18·81	19·76	20·72	21·69	22·65	23·62	24·59	25·56	26·52	27·49	48
49	18·83	19·78	20·74	21 70	22·67	23·64	24·61	25·57	26·54	27·50	49
50	18·84	19·80	20·76	21·72	22·69	23·65	24·62	25·59	26·56	27·52	50
51	18·86	19·81	20·77	21·74	22·70	23·67	24·64	25·61	26·57	27·53	51
52	18 87	19·83	20·79	21·75	22·72	23·69	24·65	25·62	26·59	27·55	52
53	18·89	19 84	20·80	21·77	22·73	23·70	24·67	25·64	26·60	27·57	53
54	18·91	19·86	20·82	21·78	22·75	23·72	24·69	25·65	26·62	27·58	54
55	18·92	19·88	20·84	21·80	22·77	23·73	24·70	25·67	26·64	27·60	55
56	18·94	19·89	20·85	21·82	22·78	23·75	24·72	25·69	26·65	27·61	56
57	18·95	19·91	20·87	21·83	22·80	23·77	24·73	25·70	26·67	27·63	57
58	18·97	19·92	20·88	21·85	22·81	23·78	24·75	25·72	26·68	27·65	58
59	18·98	19·94	20·90	21·86	22·83	23·80	24·77	25·73	26·70	27·66	59
60	19·00	19·96	20·92	21·88	22·85	23·81	24·78	25·75	26·72	27·68	60

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Length of a Degree of Longitude.

′	29°	30°	31°	32°	33°	34°	35°	36°	37°	38°	′
	chains.	chains.	chains.	chains.	chains.	chains.	chains.	chains.	chains.	chains.	
0	4843·17	4795·82	4747·01	4696·75	4645·06	4591·96	4537·45	4481·56	4424·29	4365·68	0
1	42·40	95·02	46·19	95·90	44·19	91·06	36·53	80·61	23·33	64·69	1
2	41·62	94·22	45·36	95·05	43·32	90·16	35·61	79·67	22·36	63·70	2
3	40·84	93·42	44·53	94 20	42·44	89·26	34·69	78·73	21·40	62·72	3
4	40·06	92·61	43·71	93·35	41·57	88·37	33·77	77·78	20·43	61·73	4
5	39·28	91·81	42·88	92·50	40·69	87·47	32·84	76·84	19·46	60·74	5
6	38·50	91·01	42·05	91·65	39·82	86·57	31·92	75·89	18·49	59·75	6
7	37·72	90·20	41·22	90·80	38·94	85·67	31·00	74·95	17·53	58·76	7
8	36·94	89·40	40·39	89·94	38·06	84·77	30·08	74·00	16·56	57·77	8
9	36·16	88·59	39·56	89·09	37·19	83·87	29·15	73·05	15·59	56·77	9
10	35·38	87·79	38·73	88·24	36·31	82·97	28·23	72·11	14·62	55·78	10
11	34·60	86·98	37·90	87·38	35·43	82·07	27·30	71·16	13·65	54·79	11
12	33·82	86·18	37·07	86·53	34·55	81·17	26·38	70·21	12·68	53·80	12
13	33·04	85·37	36·24	85·67	33·68	80·26	25·46	69·26	11·71	52·81	13
14	32·26	84·56	35·41	84·82	32·80	79·36	24·53	68·32	10·74	51·81	14
15	31·47	83·76	34·58	83·96	31·92	78·46	23·60	67·37	09·77	50·82	15
16	30·69	82·95	33·75	83·11	31·04	77·56	22·68	66·42	08·80	49·83	16
17	29·91	82·14	32·92	82·25	30·16	76·65	21·75	65·47	07·82	48·83	17
18	29·12	81·33	32·08	81·40	29·28	75·75	20·83	64·52	06·85	47·84	18
19	28·34	80·52	31·25	80·54	28·40	74·85	19·90	63·57	05·88	46·84	19
20	27·55	79·71	30·42	79·68	27·52	73·94	18·97	62·62	04·91	45·85	20
21	26·77	78·90	29·58	78 82	26·64	73·04	18·04	61·67	03·93	44·85	21
22	25·98	78·09	28·75	77·97	25·75	72·13	17·11	60·72	02·96	43·85	22
23	25·20	77·28	27·92	77·11	24 87	71·23	16·19	59·77	01·98	42·86	23
24	24·41	76·47	27·08	76·25	23·99	70·32	15·26	58·81	01·01	41·86	24
25	23·62	75·66	26·25	75·39	23·11	69 41	14·33	57·86	00·04	40 86	25
26	22·83	74·85	25·41	74·53	22.22	68·51	13·40	56·91	4399·06	39·87	26
27	22·05	74 04	24·57	73·67	21·34	67·60	12·47	55 96	98·08	38·87	27
28	21·26	73·22	23·74	72·81	20·45	66·69	11·54	55·00	97·11	37·87	28
29	20·47	72·41	22·90	71·95	19·57	65·78	10·61	54·05	96·13	36·87	29
30	19·68	71·60	22·06	71·09	18·69	64·88	09·67	53·09	95·16	35·87	30
31	18·89	70·78	21·22	70·22	17·80	63·97	08·74	52·14	94·18	34·87	31
32	18·10	69·97	20·39	69·36	16·91	63·06	07·81	51·19	93·20	33·87	32
33	17·31	69·16	19·55	68·50	16·03	62·15	06·88	50·23	92·22	32·87	33
34	16·52	68·34	18·71	67·64	15·14	61·24	05·94	49·27	91·25	31·87	34
35	15·73	67 53	17·87	66·77	14·26	60·33	05·01	48·32	90·27	30·87	35
36	14·94	66·71	17·03	65·91	13·37	59·42	04·08	47·36	89·29	29·87	36
37	14·15	65·89	16·19	65·05	12·48	58·51	03·14	46·41	88·31	28·87	37
38	13·35	65·08	15·35	64·18	11·59	57·60	02·21	45·45	87·33	27·87	38
39	12·56	64·26	14·51	63·32	10·70	56·68	01·28	44·49	86·35	26·87	39
40	11·77	63·44	13·67	62·45	09·81	55·77	00·34	43·53	85·37	25·86	40
41	10·98	62·62	12·82	61·59	08·93	54·86	4499·40	42·57	84·39	24·86	41
42	10·18	61·81	11·98	60·72	08·04	53·95	98·47	41·62	83·41	23·86	42
43	09·39	60·99	11·14	59·85	07·15	53·03	97·53	40·66	82·42	22·85	43
44	08·59	60·17	10·30	58·99	06·26	52·12	96·59	39·70	81·44	21·85	44
45	07·80	59 35	09 45	58·12	05·36	51·21	95·66	38·74	80·46	20·85	45
46	07·00	58·53	08·61	57·25	04·47	50·29	94·72	37·78	79 48	19·84	46
47	06·21	57·71	07·76	56·38	03·58	4 9·38	93·78	36·82	78·49	18·84	47
48	05·41	56·89	06·92	55·51	02·69	48·46	92·84	35·86	77·51	17·83	48
49	04·61	56·07	06·07	54·65	01·80	47·55	91·91	34·89	76·53	16·82	49
50	03 82	55·25	05·23	53·78	00·90	46·63	90·97	33·93	75·54	15·82	50
51	03·02	54·43	04·38	52 91	00·01	45 71	90·03	32·97	74·56	14·81	51
52	02·22	53·60	03·54	52·04	4599·11	44·80	89·09	32·01	73·57	13·80	52
53	01·42	52·78	02·69	51·17	98·22	43·88	88·15	31·04	72·59	12·80	53
54	00·62	51·96	01·84	50 30	97·33	42·96	87·21	30·08	71·60	11·79	54
55	4799·82	51·13	01·00	49·42	96·44	42·04	86·27	29·12	70·62	10·78	55
56	99 02	50·31	00·15	48·55	95·54	41·13	85·32	28·15	69·63	09·77	56
57	98·22	49·49	4699. 30	47·68	94·64	40·21	84·38	27·19	68·64	08·76	57
58	97·42	48·66	98·45	46·81	93·75	39·29	83·44	26·22	67·66	07·75	58
59	96·62	47·84	97·60	45·94	92·85	38·37	82·50	25·26	66·67	06·74	59
60	95·82	47·01	96·75	45 06	91·96	37·45	81·56	24·29	65 68	05·73	60

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Length of a Degree of Longitude.

′	39°	40°	41°	42°	43°	44°	45°	46°	47°	48°	′
	chains.	chains.	chains.	chains.	chains.	chains.	chains.	chains.	chains.	chains.	
0	4305·73	4244·47	4181·91	4118·06	4052·96	3986·62	3919·05	3850.28	3780·33	3709·22	0
1	04·72	43·44	80·85	16·99	51·87	85·50	17·91	49·12	79·15	08·03	1
2	03·71	42·41	79·80	15·91	50·77	84·38	16·78	47·97	77·98	06·83	2
3	02·70	41·37	78·75	14·84	49·67	83·27	15·64	46·81	76·80	05·63	3
4	01·69	40·34	77·69	13·76	48·58	82·15	14·50	45·65	75·63	04·44	4
5	00·68	39·31	76·64	12·69	47·48	81·03	13·36	44·50	74·45	03·24	5
6	4299·67	38·27	75·58	11·61	46·38	79·91	12·23	43·34	73·27	02·05	6
7	98·65	37·24	74·52	10·53	45·28	78·79	11·09	42·18	72·09	00·85	7
8	97·64	36·20	73·47	09·46	44·19	77·68	09·95	41·02	70·92	3699·65	8
9	96·63	35·17	72·41	08·38	43·09	76·56	08·81	39·86	69·74	98·46	9
10	95·61	34·13	71·36	07·30	41·99	75·44	07·67	38·70	68·56	97·26	10
11	94·60	33·10	70·30	06·22	40·89	74·32	06·53	37·54	67·38	96·06	11
12	93·59	32·06	69·24	05·14	39·79	73·20	05·39	36·38	66·20	94·86	12
13	92·57	31·02	68·18	04·07	38·69	72·08	04·25	35·22	65·02	93·66	13
14	91·56	29·99	67·12	02·99	37·59	70·96	03·11	34·06	63·84	92·46	14
15	90·54	28·95	66·07	01·91	36·49	69·84	01·97	32·90	62·66	91·26	15
16	89·52	27·91	65·01	00·83	35·39	68·72	00·83	31·74	61·48	90·06	16
17	88·51	26·87	63·95	4099·75	34·29	67·59	3899·69	30·58	60·30	88·86	17
18	87·49	25·84	62·89	98·67	33·19	66·47	98·54	29·42	59·12	87·66	18
19	86·48	24·80	61·83	97·58	32·09	65·35	97·40	28·26	57·94	86·46	19
20	85·46	23·76	60·77	96·50	30·98	64·23	96·26	27·09	56·76	85·26	20
21	84·44	22·72	59·71	95·42	29·88	63·11	95·12	25·93	55·57	84·06	21
22	83·42	21·68	58·65	94·34	28·78	61·98	93·97	24·77	54·39	82·86	22
23	82·40	20·64	57·58	93·26	27·67	60·86	92·83	23·60	53·21	81·66	23
24	81·39	19·60	56·52	92·17	26·57	59·73	91·68	22·44	52·02	80·46	24
25	80·37	18·56	55·46	91·09	25·47	58·61	90·54	21·28	50·84	79·25	25
26	79·35	17·52	54·40	90·01	24·36	57·49	89·40	20·11	49·66	78·05	26
27	78·33	16·48	53·44	88·92	23·26	56·36	88·25	18·95	48·47	76·85	27
28	77·31	15·43	52·27	87·84	22·15	55·24	87·11	17·78	47·29	75·64	28
29	76·29	14·39	51·21	86·75	21·05	54·11	85·96	16·62	46·10	74·44	29
30	75·27	13·35	50·14	85·67	19·94	52·98	84·81	15·45	44·92	73·24	30
31	74·24	12·31	49·08	84·58	18·84	51·86	83·67	14·29	43·73	72·03	31
32	73·22	11·26	48·02	83·50	17·73	50·73	82·52	13·12	42·55	70·83	32
33	72·20	10·22	46·95	82·41	16·62	49·60	81·37	11·95	41·36	69·62	33
34	71·18	09·18	45·89	81·33	15·52	48·48	80·23	10·79	40·18	68·42	34
35	70·16	08·13	44·82	80·24	14·41	47·35	79·08	09·62	38·99	67·21	35
36	69·13	07·09	43·75	79·15	13·30	46·22	77·93	08·45	37·80	66·01	36
37	68·11	06·04	42·69	78·07	12·19	45·09	76·78	07·28	36·62	64·80	37
38	67·09	05·00	41·62	76·98	11·09	43·96	75·63	06·11	35·43	63·59	38
39	66·06	03·95	40·55	75·89	09·98	42·83	74·48	04·95	34·24	62·39	39
40	65·04	02·90	39·49	74·80	08·87	41·71	73·34	03·78	33·05	61·18	40
41	64·01	01·86	38·42	73·71	07·76	40·58	72·19	02·61	31·86	59·97	41
42	62·99	00·81	37·35	72·62	06·65	39·45	71·04	01·44	30·67	58·76	42
43	61·96	4199.76	36·28	71·53	05·54	38·32	69·89	00·27	29·48	57·56	43
44	60·93	98·72	35·21	70·44	04·43	37·18	68·74	3799·10	28·30	56·35	44
45	59·91	97·67	34·14	69·35	03·32	36·05	67·58	97·93	27·11	55·14	45
46	58·88	96·62	33·08	68·26	02·21	34·92	66·43	96·76	25·92	53·93	46
47	57·85	95·57	32·01	67·17	01·10	33·79	65·28	95·59	24·73	52·72	47
48	56·83	94·52	30·93	66·08	3999·98	32·66	64·13	94·41	23·53	51·51	48
49	55·80	93·47	29·86	64·99	98·87	31·53	62·98	93·24	22·34	50·30	49
50	54·77	92·42	28·79	63·90	97·76	30·39	61·82	92·07	21·15	49·09	50
51	53·74	91·37	27·72	62·81	96·65	29·26	60·67	90·90	19·96	47·88	51
52	52·71	90·32	26·65	61·71	95·53	28·13	59·52	89·72	18·77	46·67	52
53	51·68	89·27	25·58	60·62	94·42	26·99	58·36	88 55	17·58	45·46	53
54	50·66	88·22	24·51	59·53	93·31	25·86	57·21	87·38	16·38	44·25	54
55	49·63	87·17	23·43	58·43	92·19	24·73	56·06	86·20	15·19	43·03	55
56	48·59	86·12	22·36	57·34	91·08	23·59	54·90	85·03	14·00	41·82	56
57	47·56	85·07	21·29	56·25	89·96	22·46	53·75	83·86	12·80	40·61	57
58	46·53	84·02	20 21	55·15	88·85	21·32	52·59	82·68	11·61	39·40	58
59	45·50	82·96	19·14	54·06	87·73	20·19	51·44	81·51	10·41	38·18	59
60	44·47	81·91	18·06	52·96	86·62	19·05	50·28	80·33	09·22	36·97	60

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Arc in Equivalents of Sideral Time.

Arc.	Time.	Arc.	Time.	Arc.	Time.	Arc.	Time.	Arc.	Time.
″	s.	′	m. s.	°	h. m.	°	h. m.	°	h. m.
1	0·07	1	0 4	1	0 4	61	4 4	121	8 4
2	0·13	2	0 8	2	0 8	62	4 8	122	8 8
3	0·20	3	0 12	3	0 12	63	4 12	123	8 12
4	0·27	4	0 16	4	0 16	64	4 16	124	8 16
5	0·33	5	0 20	5	0 20	65	4 20	125	8 20
6	0·40	6	0 24	6	0 24	66	4 24	126	8 24
7	0·47	7	0 28	7	0 28	67	4 28	127	8 28
8	0·53	8	0 32	8	0 32	68	4 32	128	8 32
9	0·60	9	0 36	9	0 36	69	4 36	129	8 36
10	0·67	10	0 40	10	0 40	70	4 40	130	8 40
11	0·73	11	0 44	11	0 44	71	4 44	131	8 44
12	0·80	12	0 48	12	0 48	72	4 48	132	8 48
13	0·87	13	0 52	13	0 52	73	4 52	133	8 52
14	0·93	14	0 56	14	0 56	74	4 56	134	8 56
15	1·00	15	1 0	15	1 0	75	5 0	135	9 0
16	1·07	16	1 4	16	1 4	76	5 4	136	9 4
17	1·13	17	1 8	17	1 8	77	5 8	137	9 8
18	1·20	18	1 12	18	1 12	78	5 12	138	9 12
19	1·27	19	1 16	19	1 16	79	5 16	139	9 16
20	1·33	20	1 20	20	1 20	80	5 20	140	9 20
21	1·40	21	1 24	21	1 24	81	5 24	141	9 24
22	1·47	22	1 28	22	1 28	82	5 28	142	9 28
23	1·53	23	1 32	23	1 32	83	5 32	143	9 32
24	1·60	24	1 36	24	1 36	84	5 36	144	9 36
25	1·67	25	1 40	25	1 40	85	5 40	145	9 40
26	1·73	26	1 44	26	1 44	86	5 44	146	9 44
27	1·80	27	1 48	27	1 48	87	5 48	147	9 48
28	1·87	28	1 52	28	1 52	88	5 52	148	9 52
29	1·93	29	1 56	29	1 56	89	5 56	149	9 56
30	2·00	30	2 0	30	2 0	90	6 0	150	10 0
31	2·07	31	2 4	31	2 4	91	6 4	151	10 4
32	2·13	32	2 8	32	2 8	92	6 8	152	10 8
33	2·20	33	2 12	33	2 12	93	6 12	153	10 12
34	2·27	34	2 16	34	2 16	94	6 16	154	10 16
35	2·33	35	2 20	35	2 20	95	6 20	155	10 20
36	2·40	36	2 24	36	2 24	96	6 24	156	10 24
37	2·47	37	2 28	37	2 28	97	6 28	157	10 28
38	2·53	38	2 32	38	2 32	98	6 32	158	10 32
39	2·60	39	2 36	39	2 36	99	6 36	159	10 36
40	2·67	40	2 40	40	2 40	100	6 40	160	10 40
41	2·73	41	2 44	41	2 44	101	6 44	161	10 44
42	2·80	42	2 48	42	2 48	102	6 48	162	10 48
43	2·87	43	2 52	43	2 52	103	6 52	163	10 52
44	2·93	44	2 56	44	2 56	104	6 56	164	10 56
45	3·00	45	3 0	45	3 0	105	7 0	165	11 0
46	3·07	46	3 4	46	3 4	106	7 4	166	11 4
47	3·13	47	3 8	47	3 8	107	7 8	167	11 8
48	3·20	48	3 12	48	3 12	108	7 12	168	11 12
49	3·27	49	3 16	49	3 16	109	7 16	169	11 16
50	3·33	50	3 20	50	3 20	110	7 20	170	11 20
51	3·40	51	3 24	51	3 24	111	7 24	171	11 24
52	3·47	52	3 28	52	3 28	112	7 28	172	11 28
53	3·53	53	3 32	53	3 32	113	7 32	173	11 32
54	3·60	54	3 36	54	3 36	114	7 36	174	11 36
55	3·67	55	3 40	55	3 40	115	7 40	175	11 40
56	3·73	56	3 44	56	3 44	116	7 44	176	11 44
57	3·80	57	3 48	57	3 48	117	7 48	177	11 48
58	3·87	58	3 52	58	3 52	118	7 52	178	11 52
59	3 93	59	3 56	59	3 56	119	7 56	179	11 56
60	4·00	60	4 0	60	4 0	120	8 0	180	12 0

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Sideral Time in Equivalents of Arc.

Time.	Arc.	Time.	Arc.	Time.	Arc.	Time.	Arc.
s.	″	s.	′ ″	m. s.	° ′ ″	h. m.	° ′
·01	0·15	0·61	0 9·15	0 22	0 5 30	0 28	5 45
·02	0·30	·62	9·30	23	5 45	24	6 0
·03	0·45	·63	9·45	24	6 0	25	6 15
·04	0·60	·64	9·60	25	6 15	26	6 30
·05	0·75	·65	9·75	26	6 30	27	6 45
·06	0·90	·66	9·90	27	6 45	28	7 0
·07	1·05	·67	10·05	28	7 0	29	7 15
·08	1·20	·68	10·20	29	7 15	30	7 30
·09	1·35	·69	10·35	30	7 30	31	7 45
·10	1·50	·70	10·50	31	7 45	32	8 0
·11	1·65	·71	10·65	32	8 0	33	8 15
·12	1·80	·72	10·80	33	8 15	34	8 30
·13	1·95	·73	10·95	34	8 30	35	8 45
·14	2·10	·74	11·10	35	8 45	36	9 0
·15	2·25	·75	11·25	36	9 0	37	9 15
·16	2·40	·76	11·40	37	9 15	38	9 30
·17	2·55	·77	11·55	38	9 30	39	9 45
·18	2·70	·78	11·70	39	9 45	40	10 0
·19	2·85	·79	11·85	40	10 0	41	10 15
·20	3·00	·80	12·00	41	10 15	42	10 30
·21	3·15	·81	12·15	42	10 30	43	10 45
·22	3·30	·82	12·30	43	10 45	44	11 0
·23	3·45	·83	12·45	44	11 0	45	11 15
·24	3·60	·84	12·60	45	11 15	46	11 30
·25	3·75	·85	12·75	46	11 30	47	11 45
·26	3·90	·86	12·90	47	11 45	48	12 0
·27	4·05	·87	13·05	48	12 0	49	12 15
·28	4·20	·88	13·20	49	12 15	50	12 30
·29	4 35	·89	13 35	50	12 30	51	12 45
·30	4·50	·90	13·50	51	12 45	52	13 0
·31	4·65	·91	13·65	52	13 0	53	13 15
·32	4 80	·92	13·80	53	13 15	54	13 30
·33	4·95	·93	13·95	54	13 30	55	13 45
·34	5·10	·94	14·10	55	13 45	56	14 0
·35	5·25	·95	14·25	56	14 0	57	14 15
·36	5·40	·96	14·40	57	14 15	58	14 30
·37	5·55	·97	14·55	58	14 30	59	14 45
·38	5·70	·98	14·70	59	14 45	1	15
·39	5·85	·99	14·85	1	15	2	30
·40	6·00	1	15	2	30	3	45
·41	6·15	2	30	3	45	4	60
·42	6·30	3	45	4	1 0	5	75
·43	6·45	4	1 0	5	1 15	6	90
·44	6·60	5	1 15	6	1 30	7	105
·45	6·75	6	1 30	7	1 45	8	120
·46	6·90	7	1 45	8	2 0	9	135
·47	7·05	8	2 0	9	2 15	10	150
·48	7·20	9	2 15	10	2 30	11	165
·49	7·35	10	2 30	11	2 45	12	180
·50	7·50	11	2 45	12	3 0	13	195
·51	7·65	12	3 0	13	3 15	14	210
·52	7·80	13	3 15	14	3 30	15	225
·53	7·95	14	3 30	15	3 45	16	240
·54	8·10	15	3 45	16	4 0	17	255
·55	8·25	16	4 0	17	4 15	18	270
·56	8·40	17	4 15	18	4 30	19	285
·57	8·55	18	4 30	19	4 45	20	300
·58	8·70	19	4 45	20	5 0	21	315
·59	8·85	20	5 0	21	5 15	22	330
·60	9·00	21	5 15	22	5 30	23	345

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Mean Solar Time in Equivalent Intervals of Sideral Time.

Sol. T.	Sid. T.	Sol. T.	Sid. T.	Sol. T.	Sid. Time.	Sol. T.	Sid. Time.
s.	s.	s.	s.	m. s.	m. s.	h. m.	h. m. s
·01	·010	·61	·612	0 22	0 22·060	0 23	0 23 3·778
·02	·020	·62	·622	23	23·068	24	24 3·943
·03	·030	·63	·632	24	24·066	25	25 4·107
·04	·040	·64	·642	25	25·068	26	26 4·271
·05	·050	·65	·652	26	26·071	27	27 4·435
·06	·060	·66	·662	27	27·074	28	28 4·600
·07	·070	·67	·672	28	28·077	29	29 4·764
·08	·080	·68	·682	29	29·079	30	30 4·928
·09	·090	·69	·692	30	30·082	31	31 5·093
·10	·100	·70	·702	31	31·085	32	32 5·257
·11	·110	·71	·712	32	32·088	33	33 5 421
·12	·120	·72	·722	33	33·090	34	34 5·585
·13	·130	·73	·732	34	34·093	35	35 5·750
·14	·140	·74	·742	35	35·096	36	36 5·914
·15	·150	·75	·752	36	36·099	37	37 6·078
·16	·160	·76	·762	37	37·101	38	38 6·242
·17	·170	·77	·772	38	38·104	39	39 6·407
·18	·180	·78	·782	39	39·107	40	40 6 571
·19	·191	·79	·792	40	40·110	41	41 6·735
·20	·201	·80	·802	41	41·112	42	42 6·900
·21	·211	·81	·812	42	42·115	43	43 7·064
·22	·221	·82	·822	43	43·118	44	44 7·228
·23	·231	·83	·832	44	44·120	45	45 7·392
·24	·241	·84	·842	45	45·123	46	46 7·557
·25	·251	·85	·852	46	46·126	47	47 7·721
·26	·261	·86	·862	47	47·129	48	48 7 885
·27	·271	·87	·872	48	48·131	49	49 8·049
·28	·281	·88	·882	49	49·134	50	50 8·214
·29	·291	·89	·892	50	50·137	51	51 8·378
·30	·301	·90	·902	51	51·140	52	52 8·542
·31	·311	·91	·912	52	52 142	53	53 8·707
·32	·321	·92	·928	53	53·145	54	54 8·871
·33	·331	·93	·933	54	54·148	55	55 9·035
·34	·341	·94	·943	55	55·151	56	56 9·199
·35	·351	·95	·953	56	56·153	57	57 9·364
·36	·361	·96	·963	57	57 156	58	58 9·528
·37	·371	·97	·973	58	58·159	59	59 9·692
·38	·381	·98	·983	59	59·162	1	1 0 9·856
·39	·391	·99	·993	1	1 0·164	2	2 0 19·713
·40	·401	1	1·003	2	2 0·329	3	3 0 29·569
·41	·411	2	2·005	3	3 0·493	4	4 0 39·426
·42	·421	3	3·008	4	4 0·657	5	5 0 49·282
·43	·431	4	4·011	5	5 0·821	6	6 0 59·139
·44	·441	5	5·014	6	6 0·986	7	7 1 8·995
·45	·451	6	6·016	7	7 1·150	8	8 1 18 852
·46	·461	7	7·019	8	8 1·314	9	9 1 28·708
·47	·471	8	8·022	9	9 1·478	10	10 1 38·565
·48	·481	9	9·025	10	10 1·643	11	11 1 48·421
·49	·491	10	10·027	11	11 1·807	12	12 1 58·278
·50	·501	11	11·030	12	12 1·971	13	13 2 8·134
·51	·511	12	12·033	13	13 2·136	14	14 2 17·991
·52	·521	13	13·036	14	14 2·300	15	15 2 27·847
·53	·531	14	14·038	15	15 2·464	16	16 2 37·704
·54	·541	15	15·041	16	16 2·628	17	17 2 47·560
·55	·552	16	16·044	17	17 2·793	18	18 2 57·417
·56	·562	17	17·047	18	18 2·957	19	19 3 7·273
·57	·572	18	18·049	19	19 3·121	20	20 3 17·129
·58	·582	19	19·052	20	20 3·285	21	21 3 26·986
·59	·592	20	20·055	21	21 3·450	22	22 3 36·842
·60	·602	21	21·057	22	22 3·614	23	23 3 46·699

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Sideral Time in Equivalent Intervals of Mean Solar Time.

Sid. T.	Sol. T.	Sid. T.	Sol. T.	Sid. T.	Solar Time.	Sid. T.	Sol. Time.
s.	s.	s.	s.	m. s.	m. s.	h. m.	h. m. s.
·01	·010	·61	·608	0 22	0 21·940	0 23	0 22 56·232
·02	·020	·62	·618	23	22·937	24	23 56 0·8
·03	·030	·63	·628	24	23·934	25	24 55·904
·04	·040	·64	·638	25	24·932	26	25 55·741
·05	·050	·65	·648	26	25·929	27	26 55·577
·06	·060	·66	·658	27	26·926	28	27 55·418
·07	·070	·67	·668	28	27·924	29	28 55·249
·08	·080	·68	·678	29	28·921	30	29 55·(85
·09	·090	·69	·688	30	29·918	31	30 54·921
·10	·100	·70	698	31	30·915	32	31 54·758
·11	·110	·71	·708	32	31 913	33	32 54·594
·12	·120	·72	·718	33	32·910	34	33 54·430
·13	·130	·73	·728	34	33·907	35	34 54·266
·14	·140	·74	·738	35	34·904	36	35 54·102
·15	·150	·75	·748	36	35·902	37	36 53·988
·16	·160	·76	·758	37	36·899	38	37 53·775
·17	·170	·77	·768	38	37·896	39	38 53·611
·18	·180	·78	·778	39	38·894	40	39 53·447
·19	·189	·79	·788	40	39·891	41	40 53·283
·20	·199	·80	·798	41	40·888	42	41 53·119
·21	·209	·81	·808	42	41·885	43	42 52·955
·22	·219	·82	·818	43	42·883	44	43 52·792
·23	·229	·83	·828	44	43 880	45	44 52·628
·24	·239	·84	·838	45	44·877	46	45 52·464
·25	·249	·85	·848	46	45·874	47	46 52 300
·26	·259	·86	·858	47	46·872	48	47 52·136
·27	·269	·87	·868	48	47·869	49	48 51·978
·28	·279	·88	·878	49	48·866	50	49 51·809
·29	·289	·89	·888	50	49·863	51	50 51·645
·30	·299	·90	·898	51	50·861	52	51 51·481
·31	·309	·91	·908	52	51·858	53	52 51·317
·32	·319	·92	·917	53	52·855	54	53 51·153
·33	·329	·93	·927	54	53·853	55	54 50·990
·34	·339	·94	·937	55	54·850	56	55 50·826
·35	·349	·95	·947	56	55·847	57	56 50·662
·36	·359	·96	·957	57	56·844	58	57 50·498
·37	·369	·97	·967	58	57·842	59	58 50·334
·38	·379	·98	·977	59	58·839	1	59 50·170
·39	·389	·99	·987	1	59·836	2	1 59 40·841
·40	·399	1	·997	2	1 59·672	3	2 59 30·511
·41	·409	2	1·995	3	2 59·509	4	3 59 20·682
·42	·419	3	2·992	4	3 59·345	5	4 59 10·852
·43	·429	4	3·989	5	4 59·181	6	5 59 1·023
·44	·439	5	4·986	6	5 59·017	7	6 58 51·193
·45	·449	6	5·984	7	6 58 853	8	7 58 41·364
·46	·459	7	6·981	8	7 58·689	9	8 58 31·534
·47	·469	8	7·978	9	8 58·526	10	9 58 21·704
·48	·479	9	8·975	10	9 58·362	11	10 58 11·875
·49	·489	10	9·973	11	10 58·198	12	11 58 2·045
·50	·499	11	10·970	12	11 58·034	13	12 57 52·216
·51	·509	12	11·967	13	12 57·870	14	13 57 42·386
·52	·519	13	12·965	14	13 57·706	15	14 57 32·557
·53	·529	14	13·962	15	14 57·543	16	15 57 22·727
·54	·539	15	14·959	16	15 57·379	17	16 57 12·897
·55	·548	16	15·956	17	16 57·215	18	17 57 3·068
·56	·558	17	16·954	18	17 57·051	19	18 56 53·238
·57	·568	18	17·951	19	18 56·887	20	19 56 43·409
·58	·578	19	18·948	20	19 56·723	21	20 56 33·579
·59	·588	20	19·945	21	20 56·560	22	21 56 23·750
·60	·598	21	20·943	22	21 56 396	23	22 56 13 920

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Azimuths of Polaris.

Sideral Time.	Latitudes.											Sideral Time.
West.	28°	30°	32°	34°	36°	38°	40°	42°	44°	46°	48°	East.
h. m.	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	h. m.
0 4	0 2	0 2	0 2	0 2	0 2	0 2	0 2	0 2	0 2	0 2	0 2	23 56
0 8	3	4	4	4	4	4	4	4	4	4	5	23 52
0 12	5	5	5	6	6	6	6	6	6	7	7	23 48
0 16	7	7	7	7	8	8	8	8	9	9	9	23 44
0 20	9	9	9	9	9	10	10	10	11	11	12	23 40
0 24	10	11	11	11	11	12	12	12	13	13	14	23 36
0 28	12	12	13	13	13	14	14	14	15	16	16	23 32
0 32	14	14	14	15	15	16	16	17	17	18	18	23 28
0 36	15	16	16	17	17	17	18	19	19	20	21	23 24
0 40	17	18	18	18	19	19	20	21	21	22	23	23 20
0 44	19	19	20	20	21	21	22	23	23	24	25	23 16
0 48	21	21	21	22	23	23	24	25	25	26	28	23 12
0 52	22	23	23	24	24	25	26	27	28	29	30	23 8
0 56	24	24	25	26	26	27	28	29	30	31	32	23 4
1 0	26	26	27	27	28	29	30	31	32	33	34	23 0
1 5	28	28	29	30	31	31	32	33	34	36	37	22 55
1 10	30	30	31	32	33	34	35	36	37	38	40	22 50
1 15	32	32	33	34	35	36	37	38	39	41	43	22 45
1 20	34	35	35	36	37	38	39	41	42	44	45	22 40
1 25	36	37	37	38	39	40	42	43	44	46	48	22 35
1 30	38	39	39	40	41	43	44	45	47	49	51	22 30
1 35	40	41	42	43	44	45	46	48	49	51	53	22 25
1 40	42	43	44	45	46	47	49	50	52	54	56	22 20
1 45	44	45	46	47	48	49	51	52	54	56	58	22 15
1 50	46	47	48	49	50	51	53	55	57	59	1 1	22 10
1 55	48	49	50	51	52	54	55	57	59	1 1	4	22 5
2 0	49	50	52	53	54	56	57	59	1 1	4	6	22 0
2 5	51	52	53	55	56	58	59	1 1	3	6	8	21 55
2 10	53	54	55	57	58	1 0	1 2	4	6	8	11	21 50
2 15	55	56	57	59	1 0	2	4	6	8	10	13	21 45
2 20	57	58	59	1 1	2	4	6	8	10	13	16	21 40
2 25	58	1 0	1 1	2	4	6	8	10	12	15	18	21 35
2 30	1 0	1	3	4	6	8	10	12	14	17	20	21 30
2 35	2	3	4	6	8	10	12	14	16	19	22	21 25
2 40	3	5	6	8	9	11	14	16	18	21	25	21 20
2 45	5	6	8	9	11	13	15	18	20	23	27	21 15
2 50	7	8	10	11	13	15	17	20	22	26	29	21 10
2 55	8	10	11	13	15	17	19	22	24	27	31	21 5
3 0	10	11	13	14	16	18	21	23	26	29	33	21 0
3 6	11	13	15	16	18	20	23	25	28	32	35	20 54
3 12	13	15	16	18	20	22	25	28	31	34	38	20 48
3 18	15	16	18	20	22	24	27	30	33	36	40	20 42
3 24	16	18	20	22	24	26	29	31	35	38	42	20 36
3 30	18	20	21	23	26	28	30	33	37	40	44	20 30
3 37	20	21	23	25	27	30	32	35	39	42	46	20 23
3 44	22	23	25	27	29	32	34	37	41	44	49	20 16
3 51	23	25	27	29	31	34	36	39	43	46	51	20 9
4 0	25	27	29	31	33	36	38	42	45	49	53	20 0
4 10	27	29	31	33	35	38	41	44	47	51	56	19 50
4 20	29	31	33	35	37	40	43	46	50	54	58	19 40
4 30	31	32	34	37	39	42	45	48	52	56	2 0	19 30
4 45	33	35	37	39	42	44	47	51	54	59	3	19 15
5 0	35	37	39	41	43	46	49	53	56	2 1	5	19 0
5 20	36	38	40	43	45	48	51	55	58	3	7	18 40
6 0	38	40	42	44	47	50	53	56	2 0	4	9	18 0

I. To the sideral time at mean noon, on any day, add the sideral equivalent of the mean time of observation, diminished by the right ascension of Polaris, and the remainder will be the sideral time of the star from the meridian.

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Azimuths of Polaris.

Sideral Time.	Latitudes.										Sideral Time.
West.	28°	30°	32°	34°	36°	38°	40°	42°	44°	46°	48°	East.
h. m.	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	h. m.
11 56	0 2	0 2	0 2	0 2	0 2	0 2	0 2	0 2	0 2	0 2	0 2	12 4
11 52	3	3	4	4	4	4	4	4	4	4	4	12 8
11 48	5	5	5	5	5	6	6	6	6	6	7	12 12
11 44	7	7	7	7	7	7	8	8	8	8	9	12 16
11 40	8	9	9	9	9	10	10	10	10	11	11	12 20
11 36	10	10	10	11	11	11	11	12	12	13	13	12 24
11 32	12	12	12	12	13	13	13	14	14	15	15	12 28
11 28	13	14	14	14	15	15	15	16	16	17	17	12 32
11 24	15	15	16	16	16	17	17	18	18	19	20	12 36
11 20	17	17	17	18	18	19	19	20	20	21	22	12 40
11 16	18	19	19	20	20	20	21	22	22	23	24	12 44
11 12	20	20	21	21	22	22	23	24	24	25	26	12 48
11 8	22	22	22	23	24	24	25	26	26	27	28	12 52
11 4	23	24	24	25	25	26	27	27	28	29	30	12 56
11 0	25	25	26	26	27	28	29	29	30	31	32	13 0
10 55	27	27	28	29	29	30	31	32	33	34	35	13 5
10 50	29	30	30	31	31	32	33	34	35	36	38	13 10
10 45	31	32	32	33	34	35	35	37	38	39	40	13 15
10 40	33	34	34	35	36	37	38	39	40	41	43	13 20
10 35	35	36	36	37	38	39	40	41	42	44	45	13 25
10 30	37	38	38	39	40	41	42	44	45	46	48	13 30
10 25	39	40	40	41	42	43	44	46	47	49	51	13 35
10 20	41	42	42	43	44	45	47	48	50	51	53	13 40
10 15	43	43	44	45	46	48	49	50	52	54	56	13 45
10 10	45	45	46	47	48	50	51	53	54	56	58	13 50
10 5	47	47	48	49	50	52	53	55	56	58	1 1	13 55
10 0	48	49	50	51	52	54	55	57	59	1 1	3	14 0
9 55	50	51	52	53	54	56	57	59	1 1	3	5	14 5
9 50	52	53	54	55	56	58	59	1 1	3	5	8	14 10
9 45	54	55	56	57	58	1 0	1 1	3	5	8	10	14 15
9 40	55	56	58	59	1 0	2	3	5	7	10	12	14 20
9 35	57	58	59	1 1	2	4	5	7	10	12	15	14 25
9 30	59	1 0	1 1	2	4	6	7	9	12	14	17	14 30
9 25	1 1	2	3	4	6	7	9	11	14	16	19	14 35
9 20	2	3	5	6	8	9	11	13	16	18	21	14 40
9 15	4	5	6	8	9	11	13	15	18	20	23	14 45
9 10	5	7	8	9	11	13	15	17	20	22	25	14 50
9 5	7	8	10	11	13	15	17	19	21	24	27	14 55
9 0	8	10	11	13	14	16	18	21	23	26	29	15 0
8 54	10	12	13	15	16	18	20	23	26	28	32	15 6
8 48	12	13	15	16	18	20	22	25	28	31	34	15 12
8 42	14	15	17	18	20	22	24	27	30	33	36	15 18
8 36	15	17	18	20	22	24	26	29	32	35	38	15 24
8 30	17	18	20	22	24	26	28	31	34	37	40	15 30
8 23	19	20	22	24	26	28	30	33	36	39	43	15 37
8 16	20	22	24	25	27	30	32	35	38	41	45	15 44
8 9	22	24	25	27	29	32	34	37	40	44	47	15 51
8 0	24	26	27	29	31	34	36	39	43	46	50	16 0
7 50	26	28	30	32	34	36	39	42	45	49	53	16 10
7 40	28	30	32	34	36	38	41	44	48	51	55	16 20
7 30	30	31	33	35	38	40	43	46	50	54	58	16 30
7 15	32	34	36	38	40	43	46	49	53	57	2 1	16 45
7 0	34	36	38	40	42	45	48	51	55	59	4	17 0
6 40	36	38	40	42	45	47	50	54	58	2 2	6	17 20
6 0	38	40	42	44	47	50	53	56	2 0	4	9	18 0

II. Find, in one of the right or left hand columns of the table, the sideral time of Polaris from the meridian; and opposite to it, under the latitude of the place, will be found the azimuth of the star, east or west, as indicated at the head of the column.

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Altitudes by the Barometer.

Observed Hights of the Barometer at Lower and Upper Stations, H, H′.

H.H′	N. N′.	Diff.	H H′	N. N′.	Diff.	H H′	N. N′.	Diff.	H H′	N. N′.	Diff.
inch	feet.		inch	feet.		inch	feet.		inch	feet.	
11·0	1396·9		16·0	11186·3		21·0	18291·0		26·0	23871·0	
		236·4			162·8			124·1			100·3
11·1	1633·3		16·1	11349·1		21·1	18415·1		26·1	23971·3	
		234·3			161·8			123·6			99·9
11·2	1867·6		16·2	11510·9		21·2	18538·7		26·2	24071·2	
		232·3			160·8			122·9			99·5
11·3	2099·9		16·3	11671·7		21·3	18661·6		26·3	24170·7	
		230·2			159·8			122·4			99·1
11·4	2330·1		16·4	11831·5		21·4	18784·0		26·4	24269·8	
		228·2			158·8			121·8			98·8
11·5	2558·3		16·5	11990·3		21·5	18905·8		26·5	24368·6	
		226·2			157·9			121·2			98·4
11·6	2784·5		16·6	12148·2		21·6	19027·0		26·6	24467·0	
		224·2			156·9			120·7			98·1
11·7	3008·7		16·7	12305·1		21·7	19147·7		26·7	24565·1	
		222·4			155·9			120·1			97·6
11·8	3231·1		16·8	12461·0		21·8	19267·8		26·8	24662·7	
		220·5			155·1			119·6			97·3
11·9	3451·6		16·9	12616·1		21·9	19387·4		26·9	24760·0	
		218·6			154·1			119·0			97·0
12·0	3670·2		17·0	12770·2		22·0	19506·4		27·0	24857·0	
		216·8			153·3			118·5			96·6
12·1	3887·0		17·1	12923·5		22·1	19624·9		27·1	24953·6	
		215·0			152·3			118·0			96·2
12·2	4102·0		17·2	13075·8		22·2	19742·9		27·2	25049·8	
		213·3			151·5			117·4			95·9
12·3	4315·3		17·3	13227·3		22·3	19860·3		27·3	25145·7	
		211·6			150·6			116·9			95·5
12·4	4526·9		17·4	13377·9		22·4	19977·2		27·4	25241·2	
		209·8			149 7			116·4			95·2
12·5	4736·7		17·5	13527·6		22·5	20093·6		27·5	25336·4	
		208·2			148·9			115·8			94·8
12·6	4944·9		17·6	13676·5		22·6	20209·4		27·6	25431·2	
		206·5			148 0			115·4			94·5
12·7	5151·4		17·7	13824·5		22·7	20324·8		27·7	25525·7	
		205·0			147·2			114·8			94·2
12·8	5356·4		17·8	13971·7		22·8	20439·6		27·8	25619·9	
		203·3			146·3			114·4			93·8
12·9	5559·7		17·9	14118·0		22·9	20554·0		27·9	25713·7	
		201·7			145·6			113·8			93·4
13·0	5761·4		18·0	14263 6		23·0	20667·8		28·0	25807·1	
		200·2			144·7			113·3			93·2
13·1	5961·6		18·1	14408·3		23·1	20781·1		28·1	25900·3	
		198·7			144·0			112·9			92·8
13·2	6160·3		18·2	14552·3		23·2	20894·0		28·2	25993·1	
		197·2			143·1			112·4			92 5
13·3	6357·5		18·3	14695·4		23·3	21006·4		28·3	26085·6	
		195·7			142·4			111·9			92·1
13·4	6553·2		18·4	14837·8		23·4	21118·3		28·4	26177·7	
		194·3			141·6			111·4			91·9
13·5	6747·5		18·5	14979·4		23·5	21229·7		28·5	26269·6	
		192·8			140·9			110·9			91·5
13·6	6940·3		18·6	15120·3		23·6	21340·6		28·6	26361·1	
		191·4			140·0			110·5			91·2
13·7	7131·7		18·7	15260 3		23·7	21451·1		28·7	26452·3	
		190·0			139·4			110·0			90·9
13·8	7321 7		18·8	15399·7		23·8	21561·1		28·8	26543·2	
		188·6			138·3			109·5			90 5
13·9	7510·3		18 9	15538·3		23·9	21670·6		28·9	26633·7	
		187 3			137·9			109 1			90·3
14·0	7697·6		19·0	15676·2		24 0	21779·7		29·0	26724·0	
		186·0			137·1			108·7			89·9
14·1	7883 6		19·1	15813 3		24·1	21888·4		29·1	26813·9	
		184·6			136·5			108·2			89·6
14·2	8068·2		19·2	15949·8		24·2	21996·6		29·2	26903·5	
		183·3			135·7			107·7			89·3
14·3	8251·5		19·3	16085·5		24·3	22104·3		29·3	26992·8	
		182 1			135·0			107·3			89·1
14·4	8433·6		19·4	16220·5		24·4	22211·6		29·4	27081·9	
		180·8			134·3			106·8			88·7
14·5	8614·4		19 5	16354·8		24·5	22318·4		29·5	27170·6	
		179·6			133·7			106·4			88·4
14·6	8794·0		19·6	16488·5		24·6	22424·8		29·6	27259·0	
		178·3			132 9			106·0			88·1
14 7	8972·3		19·7	16621·4		24·7	22530·8		29·7	27347·1	
		177·2			132·3			105 6			87·8
14·8	9149·5		19·8	16753·7		24·8	22636·4		29·8	27434·9	
		176·0			131·6			105·1			87·6
14·9	9325·5		19·9	16885·3		24 9	22741·5		29·9	27522·5	
		174·8			131·0			104 8			87·2
15·0	9500·3		20 0	17016·3		25·0	22846·3		30·0	27609·7	
		173·5			130·3			104·3			86·9
15·1	9673 8		20·1	17146·6		25·1	22950·6		30·1	27696·6	
		172·4			129·7			103·8			86·7
15·2	9846·2		20·2	17276·3		25·2	23054·4		30·2	27783·3	
		171·3			129·0			103·5			86·4
15·3	10017·5		20·3	17405·3		25·3	23157·9		30·3	27869 7	
		170·2			128 4			103·1			86 0
15 4	10187·7		20·4	17533 7		25·4	23261·0		30·4	27955·7	
		169·1			127·7			102·6			85·8
15·5	10356·8		20·5	17661 4		25·5	23363·6		30·5	28041·5	
		168 0			127·2			102·3			85·6
15·6	10524·8		20·6	17788·6		25·6	23465·9		30·6	28127·1	
		167·0			126 5			101·8			85·2
15·7	10691·8		20·7	17915·1		25·7	23567·7		30·7	28212·3	
		165·9			125·9			101·5			85·0
15·8	10857·7		20·8	18041·0		25·8	23669·2		30·8	28297·3	
		164·8			125·3			101·1			84·7
15·9	11022·5		20 9	18166·3		25·9	23770·3		30·9	28382·0	
		163·8			124 7			100·7			84·4
16·0	11186·3		21·0	18291·0		26·0	23871·0		31·0	28466·4	

I. N — N′ = D, 1st ap.alt., in which { N = Tab. No. op. I. S. H. / N′ = Tab. No. op. U. S. H′. } Hight of Bar.

Temperatures of the Bar. T, T′.

II. D — 2·3409 (T — T′) = C, 2d ap. alt.

In which { T = L. Sta. / T′ = U. Sta. } Ht. of att.Th.

Temperatures of the air t, t′.

III. C +| $\frac{C}{900}$ (t+t′ — 64) = B, 3d ap.al.

In which { t = L. Sta. / t′ = U. Sta. } Ht.of det. Th.

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Altitudes by the Barometer.

Ap. Al. B.	Latitude L. 30° 60°	32° 58°	34° 56°	36° 54°	38° 52°	40° 50°	42° 48°	44° 46°	Eleva'n E	Hight of Bar. at L. Sta. S. 14 inch	16 inch	18 inch	20 inch	22 inch	24 inch	26 inch	28 inch
feet	feet	feet	feet	feet	feet	feet	ft.	ft.	feet	feet	feet	feet	feet	feet	feet	ft.	ft.
1000	1·3	1·2	1·0	0·8	0·6	0·5	0·3	0·1	2·5	1·9	1·6	1·3	1·0	0·8	0·6	0·4	0·2
1500	2·0	1·7	1·5	1·2	1·0	0·7	0·4	0·1	3·9	2·8	2·3	1·9	1·5	1·2	0·8	0·5	0·2
2000	2·6	2·3	2·0	1·6	1·3	0·9	0·6	0·2	5·2	3·8	3·1	2·5	2·0	1·5	1·1	0·7	0·3
2500	3·3	2·9	2·5	2·0	1·6	1·2	0·7	0·2	6·5	4·7	3·9	3·2	2·5	1·9	1·4	0·9	0·4
3000	4·0	3·5	3·0	2·5	1·9	1·4	0·8	0·3	7·9	5·7	4·7	3·8	3·0	2·3	1·7	1·1	0·5
3500	4·6	4·1	3·5	2·9	2·2	1·6	1·0	0·3	9·3	6·6	5·5	4·4	3·5	2·7	1·9	1·2	0·6
4000	5·3	4·6	4·0	3·3	2·6	1·8	1·1	0·4	10·8	7·6	6·3	5·1	4·0	3·1	2·2	1·4	0·7
4500	6·0	5·2	4·5	3·7	2·9	2·1	1·2	0·4	12·2	8·5	7·0	5·7	4·5	3·5	2·5	1·6	0·7
5000	6·6	5·8	5·0	4·1	3·2	2·3	1·4	0·5	13·7	9·5	7·8	6·4	5·0	3·8	2·8	1·8	0·8
5500	7·3	6·4	5·5	4·5	3·5	2·5	1·5	0·5	15·2	10·4	8·6	7·0	5·5	4·2	3·0	1·9	0·9
6000	7·9	7·0	6·0	4·9	3·8	2·8	1·7	0·6	16·7	11·4	9·4	7·6	6·0	4·6	3·3	2·1	1·0
6500	8·6	7·6	6·5	5·3	4·2	3·0	1·8	0·6	18·3	12·3	10·2	8·3	6·6	5·0	3·6	2·3	1·1
7000	9·3	8·1	7·0	5·7	4·5	3·2	1·9	0·6	19·9	13·3	11·0	8·9	7·1	5·4	3·9	2·5	1·2
7500	9·9	8·7	7·4	6·1	4·8	3·5	2·1	0·7	21·5	14·2	11·7	9·5	7·6	5·8	4·1	2·6	1·2
8000	10·6	9·3	7·9	6·6	5·1	3·7	2·2	0·7	23·1	15·2	12·5	10·2	8·1	6·2	4·4	2·8	1·3
8500	11·3	9·9	8·4	7·0	5·4	3·9	2·4	0·8	24·7	16·1	13·3	10·8	8·6	6·5	4·7	3·0	1·4
9000	11·9	10·5	8·9	7·4	5·8	4·1	2·5	0·8	26·4	17·1	14·1	11·4	9·1	6·9	5·0	3·2	1·5
9500	12·6	11·0	9·4	7·8	6·1	4·4	2·6	0·9	28·1	18·0	14·9	12·1	9·6	7·3	5·2	3·3	1·6
10000	13·2	11·6	9·9	8·2	6·4	4·6	2·8	0·9	29·8	19·0	15·7	12·7	10·1	7·7	5·5	3·5	1·7
10500	13·9	12·2	10·4	8·6	6·7	4·8	2·9	1·0	31·5	19·9	16·4	13·3	10·6	8·1	5·8	3·7	1·7
11000	14·6	12·8	10·9	9·0	7·1	5·1	3·0	1·0	33·3	20·9	17·2	14·0	11·1	8·5	6·1	3·9	1·8
11500	15·2	13·4	11·4	9·4	7·4	5·3	3·2	1·1	35·1	21·8	18·0	14·6	11·6	8·9	6·3	4·0	1·9
12000	15·9	13·9	11·9	9·8	7·7	5·5	3·3	1·1	36·9	22·8	18·8	15·3	12·1	9·2	6·6	4·2	2·0
12500	16·6	14·5	12·4	10·2	8·0	5·8	3·5	1·2	38·7	23·7	19·6	15·9	12·6	9·6	6·9	4·4	2·1
13000	17·2	15·1	12·9	10·6	8·3	6·0	3·6	1·2	40·6	24·7	20·4	16·5	13·1	10·0	7·2	4·6	2·2
13500	17·9	15·7	13·4	11·1	8·7	6·2	3·7	1·2	42·5	25·6	21·1	17·1	13·6	10·4	7·5	4·7	2·2
14000	18·5	16·3	13·9	11·5	9·0	6·4	3·9	1·3	44·4	26·6	21·9	17·8	14·1	10·8	7·7	4·9	2·3
14500	19·2	16·8	14·4	11·9	9·3	6·7	4·0	1·3	46·3	27·5	22·7	18·4	14·6	11·2	8·0	5·1	2·4
15000	19·9	17·4	14·9	12·3	9·6	6·9	4·2	1·4	48·3	28·5	23·5	19·1	15·1	11·5	8·3	5·3	2·5
15500	20·6	18·0	15·4	12·7	9·9	7·1	4·3	1·4	50·3	29·4	24·3	19·7	15·6	11·9	8·6	5·4	2·6
16000	21·2	18·6	15·9	13·1	10·3	7·4	4·4	1·5	52·3	30·4	25·1	20·3	16·1	12·3	8·8	5·6	2·7
16500	21·9	19·2	16·4	13·5	10·6	7·6	4·6	1·5	54·3	31·3	25·8	21·0	16·6	12·7	9·1	5·8	2·7
17000	22·5	19·8	16·9	13·9	10·9	7·8	4·7	1·6	56·3	32·3	26·6	21·6	17·1	13·1	9·4	6·0	2·8
17500	23·2	20·3	17·4	14·3	11·2	8·1	4·8	1·6	58·4	33·2	27·4	22·2	17·6	13·5	9·7	6·1	2·9
18000	23·8	20·9	17·9	14·7	11·5	8·3	5·0	1·7	60·5	34·2	28·2	22·9	18·1	13·8	9·9	6·3	3·0
18500	24·5	21·5	18·4	15·1	11·9	8·5	5·1	1·7	62·7	35·1	29·0	23·5	18·6	14·2	10·2	6·5	3·1
19000	25·2	22·1	18·9	15·6	12·2	8·7	5·3	1·8	64·8	36·1	29·8	24·1	19·2	14·6	10·5	6·7	3·2
19500	25·8	22·7	19·4	16·0	12·5	9·0	5·4	1·8	67·0	37·0	30·5	24·8	19·7	15·0	10·8	6·8	3·2
20000	26·5	23·2	19·9	16·4	12·8	9·2	5·5	1·8	69·2	38·0	31·3	25·4	20·2	15·4	11·0	7·0	3·3
20500	27·2	23·8	20·4	16·8	13·1	9·4	5·7	1·9	71·4	38·9	32·1	26·0	20·7	15·8	11·3	7·2	3·4
21000	27·8	24·4	20·8	17·2	13·5	9·7	5·8	1·9	73·6	39·9	32·9	26·7	21·2	16·1	11·6	7·4	3·5
21500	28·5	25·0	21·3	17·6	13·8	9·9	6·0	2·0	75·9	40·8	33·7	27·3	21·7	16·6	11·9	7·6	3·6
22000	29·1	25·6	21·8	18·0	14·1	10·1	6·1	2·0	78·2	41·8	34·5	28·0	22·2	16·9	12·1	7·7	3·7
22500	29·8	26·1	22·3	18·4	14·4	10·4	6·2	2·1	80·5	42·7	35·2	28·6	22·7	17·3	12·4	7·9	3·7
23000	30·5	26·7	22·8	18·8	14·7	10·6	6·4	2·1	82·9	43·7	36·0	29·2	23·2	17·7	12·7	8·1	3·8
23500	31·1	27·3	23·3	19·2	15·1	10·8	6·5	2·2	85·2	44·6	36·8	29·8	23·7	18·1	13·0	8·2	3·9
24000	31·8	27·9	23·8	19·7	15·4	11·0	6·6	2·2	87·6	45·6	37·6	30·5	24·2	18·5	13·2	8·4	4·0
24500	32·5	28·5	24·3	20·1	15·7	11·3	6·8	2·3	90·0	46·5	38·4	31·1	24·7	18·9	13·5	8·6	4·1
25000	33·1	29·0	24·8	20·5	16·0	11·5	6·9	2·3	92·5	47·5	39·1	31·7	25·2	19·2	13·8	8·8	4·1
25500	33·8	29·6	25·3	20·9	16·3	11·7	7·1	2·4	94·9	48·4	39·9	32·4	25·7	19·6	14·1	8·9	4·2
26000	34·4	30·2	25·8	21·3	16·7	12·0	7·2	2·4	97·4	49·4	40·7	33·0	26·2	20·0	14·4	9·1	4·3
26500	35·1	30·8	26·3	21·7	17·0	12·2	7·3	2·5	99·9	50·3	41·5	33·7	26·7	20·4	14·6	9·3	4·4
27000	35·8	31·4	26·8	22·1	17·3	12·4	7·5	2·5	102·4	51·3	42·3	34·3	27·2	20·8	14·9	9·5	4·5
27500	36·4	32·0	27·3	22·5	17·6	12·7	7·6	2·5	105·0	52·2	43·1	34·9	27·7	21·2	15·2	9.6	4·6

IV. B −|− L −|− E −|− S = A, the true altitude, in which L, E, and S are the tab. numbers, opp. the approx. alt. B, and respectively under L, E, and S; E and S being always *positive*, and L *positive south* but *negative north* of latitude 45°, where it vanishes.

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Hight of the Bar. corresponding to the Temperature of Boiling Water.

Ther.	Bar.	Ther.	Bar.	Ther.	Bar.	Ther.	Bar.	Ther.	Bar.
°	inches.	°	inches.	°	inches.	°	inches.	°	inches.
185·0	17·049	190·9	19·363	196·8	21·943	202·7	24·799	208·6	27·957
·1	·086	191·0	·409	·9	·989	·8	·850	·7	28·013
·2	·123	·1	·450	197·0	22·035	·9	·901	·8	·069
·3	·161	·2	·492	·1	·081	203·0	·952	·9	·126
·4	·198	·3	·534	·2	·128	·1	25·003	209·0	·182
·5	·236	·4	·575	·3	·174	·2	·055	·1	·239
·6	·273	·5	·617	·4	·221	·3	·106	·2	·295
·7	·310	·6	·659	·5	·267	·4	·158	·3	·352
·8	·348	·7	·701	·6	·314	·5	·210	·4	·409
·9	·386	·8	·743	·7	·361	·6	·261	·5	·466
186·0	·424	·9	·785	·8	·407	·7	·313	·6	·523
·1	·462	192·0	·827	·9	·454	·8	·365	·7	·580
·2	·500	·1	·869	198·0	·501	·9	·417	·8	·637
·3	·538	·2	·912	·1	·548	204·0	·469	·9	·695
·4	·576	·3	·954	·2	·595	·1	·521	210·0	·752
·5	·615	·4	·996	·3	·642	·2	·573	·1	·810
·6	·653	·5	20·039	·4	·689	·3	·626	·2	·867
·7	·691	·6	·082	·5	·736	·4	·678	·3	·925
·8	·730	·7	·124	·6	·784	·5	·730	·4	·983
·9	·768	·8	·167	·7	·831	·6	·783	·5	29·041
187·0	·807	·9	·210	·8	·879	·7	·836	·6	·099
·1	·846	193·0	·253	·9	·926	·8	·888	·7	·157
·2	·884	·1	·296	199·0	·974	·9	·941	·8	·215
·3	·923	·2	·339	·1	23·022	205·0	·994	·9	·274
·4	·962	·3	·382	·2	·070	·1	26·047	211·0	·332
·5	18·001	·4	·426	·3	·118	·2	·100	·1	·391
·6	·040	·5	·469	·4	·166	·3	·153	·2	·449
·7	·079	·6	·512	·5	·214	·4	·206	·3	·508
·8	·118	·7	·556	·6	·262	·5	·259	·4	·567
·9	·158	·8	·599	·7	·311	·6	·313	·5	·626
188·0	·197	·9	·643	·8	·359	·7	·366	·6	·685
·1	·236	194·0	·687	·9	·407	·8	·42	·7	·744
·2	·276	·1	·731	200·0	·456	·9	·473	·8	·803
·3	·315	·2	·775	·1	·505	206·0	·527	·9	·863
·4	·355	·3	·819	·2	·553	·1	·581	212·0	·922
·5	·395	·4	·863	·3	·602	·2	·635	·1	·982
·6	·434	·5	·907	·4	·651	·3	·689	·2	30·041
·7	·474	·6	·951	·5	·700	·4	·743	·3	·101
·8	·514	·7	·996	·6	·749	·5	·797	·4	·161
·9	·554	·8	21·040	·7	·798	·6	·852	·5	·221
189·0	·594	·9	·084	·8	·847	·7	·906	·6	·281
·1	·634	195·0	·129	·9	·897	·8	·961	·7	·341
·2	·674	·1	·174	201·0	·946	·9	27·015	·8	·401
·3	·714	·2	·218	·1	·996	207·0	·070	·9	·462
·4	·755	·3	·263	·2	24·045	·1	·125	213·0	·522
·5	·795	·4	·308	·3	·095	·2	·180	·1	·583
·6	·835	·5	·353	·4	·145	·3	·235	·2	·644
·7	·876	·6	·398	·5	·195	·4	·290	·3	·704
·8	·917	·7	·443	·6	·245	·5	·345	·4	·765
·9	·957	·8	·488	·7	·295	·6	·400	·5	·826
190·0	·998	·9	·533	·8	·345	·7	·456	·6	·887
·1	19·039	196·0	·578	·9	·395	·8	·511	·7	·948
·2	·080	·1	·623	202·0	·445	·9	·566	·8	31·009
·3	·121	·2	·669	·1	·495	208·0	·622	·9	·071
·4	·162	·3	·714	·2	·546	·1	·678	214·0	·132
·5	·203	·4	·760	·3	·596	·2	·733	·1	·198
·6	·244	·5	·806	·4	·647	·3	·789	·2	·254
·7	·285	·6	·851	·5	·697	·4	·845	·3	·316
·8	·326	·7	·897	·6	·748	·5	·901	·4	·378
·9	·368	·8	·943	·7	·799	·6	·957	·5	·440

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Atmospheric Refraction.

Ap. Al.		M'n Ref.		Ap. Al.		M'n Ref.		Ap. A	M'n Ref.		Barom. B.	Det. The. T
°	′	′	″	°	′	′	″	°	′	″	inch's	°
0	0	34	54·1	9	30	5	32·0	19	2	46·1	27·9	0·943	—18	1·150
	10	32	49·2		40	5	26·5	20	2	37·3	28·0	0·946	—16	1·145
	20	30	52·3		50	5	21·3	21	2	29·3	28·1	0·949	—14	1·140
	30	29	3·5	10	0	5	16·2	22	2	21·9	28·2	0·953	—12	1·135
	40	27	22·7		10	5	11·2	23	2	15·2	28·3	0·956	—10	1·130
	50	25	49·8		20	5	6·4	24	2	8·9	28·4	0·960	— 8	1·125
1	0	24	24·6		30	5	1·7	25	2	3·2	28·5	0·963	— 6	1·120
	10	23	6·7		40	4	57·2	26	1	57·8	28·6	0·966	— 4	1·115
	20	21	55·6		50	4	52·8	27	1	52·8	28·7	0·970	— 2	1·110
	30	20	50·9	11	0	4	48·5	28	1	48·2	28·8	0·973	0	1·106
	40	19	51·9		10	4	44·3	29	1	43·8	28·9	0·976	2	1·101
	50	18	58·0		20	4	40·2	30	1	39·7	29·0	0·980	4	1·096
2	0	18	8·6		30	4	36·3	31	1	35·8	29·1	0·983	6	1·091
	10	17	28·0		40	4	32·4	32	1	32·1	29·2	0·987	8	1·087
	20	16	40·7		50	4	28·7	33	1	28·7	29·3	0·990	10	1·082
	30	16	0·9	12	0	4	25·0	34	1	25·4	29·4	0·993	12	1·078
	40	15	23·4		10	4	21·4	35	1	22·3	29·5	0·999	14	1·073
	50	14	47·8		20	4	18·0	36	1	19·3	29·6	1·000	16	1·069
3	0	14	14·6		30	4	14·6	37	1	16·5	29·7	1·003	18	1·064
	10	13	48·7		40	4	11·3	38	1	13·8	29·8	1·007	20	1·060
	20	13	15·0		50	4	8·0	39	1	11·2	29·9	1·010	22	1·055
	30	12	48·3	13	0	4	4·9	40	1	8·7	30·0	1·014	24	1·051
	40	12	28·7		10	4	1·8	41	1	6·3	30·1	1·017	26	1·047
	50	12	0·7		20	3	58·8	42	1	4·0	30·2	1·020	28	1·042
4	0	11	33·9		30	3	55·9	43	1	1·8	30·3	1·024	30	1·038
	10	11	18·3		40	3	53·0	44	0	59·7	30·4	1·027	32	1·034
	20	10	58·6		50	3	50·2	45	0	57·7	30·5	1·031	34	1·030
	30	10	39·6	14	0	3	47·4	46	0	55·7	30·6	1·034	36	1·026
	40	10	21·2		10	3	44·7	47	0	53·8	30·7	1·037	38	1·022
	50	10	3·3		20	3	42·1	48	0	51·9	30·8	1·041	40	1·017
5	0	9	46·5		30	3	39·5	49	0	50·2	30·9	1·044	42	1·013
	10	9	30·9		40	3	37·0	50	0	48·4	31·0	1·047	44	1·009
	20	9	16·0		50	3	34·5	51	0	46·7	Att. Ther. T.		46	1·005
	30	9	1·9	15	0	3	32·1	52	0	45·1	—20°	1·005	48	1·001
	40	8	48·4		10	3	29·7	53	0	43·5	—15	1·004	50	0·998
	50	8	35·6		20	3	27·4	54	0	41·9	—10	1·004	52	0·994
6	0	8	23·3		30	3	25·1	55	0	40·4	— 5	1·003	54	0·990
	10	8	11·6		40	3	22·9	56	0	38·9	0	1·003	56	0·986
	20	8	0·3		50	3	20·7	57	0	37·5	5	1·003	58	0·982
	30	7	49·5	16	0	3	18·6	58	0	36·1	10	1·002	60	0·978
	40	7	39·2		10	3	16·5	59	0	34·7	15	1·002	62	0·975
	50	7	29·2		20	3	14·4	60	0	33·3	20	1·001	64	0·971
7	0	7	19·7		30	3	12·4	62	0	30·7	25	1·001	66	0·967
	10	7	10·5		40	3	10·4	64	0	28·2	30	1·000	68	0·964
	20	7	1·7		50	3	8·5	66	0	25·7	35	1·000	70	0·960
	30	6	58·3	17	0	3	6·6	68	0	23·3	40	0·999	72	0·956
	40	6	45·1		10	3	4·7	70	0	21·0	45	0 999	74	0 953
	50	6	37·2		20	3	2·9	72	0	18·8	50	0·998	76	0·949
8	0	6	29·6		30	3	1 1	74	0	16·6	55	0·998	78	0·946
	10	6	22·3		40	2	59·3	76	0	14·4	60	0·997	80	0·942
	20	6	15·2		50	2	57·5	78	0	12·3	65	0·997	82	0·939
	30	6	8·4	18	0	2	55·8	80	0	10·2	70	0·997	84	0·935
	40	6	1 8		10	2	54·1	82	0	8·2	75	0·996	86	0·932
	50	5	55·4		20	2	52·4	84	0	6·1	80	0·996	88	0·929
9	0	5	49·8		30	2	50·8	86	0	4·1	85	0·995	90	0·925
	10	5	43·3		40	2	49·2	88	0	2·0	90	0·995	92	0·922
	20	5	37·6		50	2	47·6	90	0	0·0	95	0·994	94	0·919

M X B X T X T′ = R, the true refraction; in which M is the mean refraction, opposite the apparent altitude; and B, T, and T′, the numbers respectively opposite the hights of the Bar. and the attached and detached Ther's.

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Divergency of the Parallel of Latitude and the Prime Vertical.

Dist	28°	30°	32°	34°	36°	38°	40°	42°	44°	46°	48°	Dist
mile	chns	chns	chns	chns	chns	chns.	chns.	chns.	chns.	chns.	chns.	mile
1	0·01	0·01	0·01	0·01	0·01	0·01	0·01	0·01	0·01	0·01	0·01	1
2	0·02	0·02	0·03	0·03	0·03	0·03	0·03	0·04	0·04	0·04	0·04	2
3	0·05	0·05	0·06	0·03	0·07	0·07	0·08	0·08	0·09	0·09	0·10	3
4	0·09	0·03	0·10	0·11	0·12	0·13	0·13	0·14	0·16	0·17	0·18	4
5	0·13	0·14	0·16	0·17	0·18	0·20	0·21	0·23	0·24	0·26	0·28	5
6	0·19	0·21	0·23	0·24	0·26	0·28	0·30	0·33	0·35	0·37	0·40	6
7	0·26	0·28	0·31	0·33	0·36	0·38	0·41	0·44	0·48	0·51	0·55	7
8	0·34	0·37	0·40	0·43	0·47	0·50	0·54	0·58	0·62	0·67	0·71	8
9	0·43	0·47	0·51	0·55	0·59	0 64	0·68	0·73	0·79	0·84	0·90	9
10	0·53	0·58	0·63	0·68	0·73	0·78	0·84	0·90	0·97	1·04	1 11	10
11	0·65	0·70	0·76	0·82	0·88	0·95	1·02	1·09	1·17	1·26	1·35	11
12	0·77	0·83	0·90	0·97	1·05	1·13	1·21	1·30	1·40	1·50	1·61	12
13	0·90	0·98	1·06	1·14	1·23	1·33	1·42	1·53	1·64	1·76	1·88	13
14	1·05	1·14	1·23	1·33	1·43	1·54	1·65	1·77	1·90	2·04	2·19	14
15	1·21	1·30	1·41	1·52	1·64	1·76	1·90	2·03	2·18	2·34	2·51	15
16	1·38	1·48	1·60	1·73	1·87	2·01	2·16	2·32	2 48	2·66	2·85	16
17	1·54	1·67	1·81	1·96	2·11	2·27	2·44	2·61	2·80	3·00	3·22	17
18	1·73	1·88	2·03	2·19	2·36	2·54	2·73	2·93	3·14	3·37	3·61	18
19	1·92	2·09	2·26	2·44	2·63	2·83	3·04	3·26	3·50	3·75	4·03	19
20	2·13	2·32	2·51	2·71	2·92	3·14	3·37	3·62	3·88	4·16	4·46	20
21	2 35	2·55	2·76	2 98	3·22	3·46	3·72	3·99	4·28	4·59	4·92	21
22	2·58	2·80	3·03	3·28	3·53	3·80	4 08	4·38	4·69	5·03	5·40	22
23	2·82	3 03	3·32	3·58	3·86	4·15	4.46	4·78	5·13	5·50	5·90	23
24	3·07	3·34	3·61	3·90	4·20	4·52	4·85	5·21	5·59	5·99	6·42	24
25	3·33	3·62	3·92	4 23	4·56	4·90	5·27	5·65	6 06	6·50	6·97	25
26	3·60	3·91	4·24	4·57	4·93	5·30	5·70	6·11	6·56	7·03	7·54	26
27	3·89	4·22	4·57	4·93	5·32	5·72	6·14	6·59	7·07	7·58	8·13	27
28	4·18	4·54	4 91	5·31	5·72	6·15	6·61	7·09	7·60	8·15	8·74	28
29	4·48	4·87	5·27	5·69	6·13	6·60	7·09	7·61	8·16	8·74	9·38	29
30	4·80	5·21	5·64	6·03	6·56	7·06	7·58	8·14	8·73	9·36	10·04	30
31	5·12	5·57	6·02	6·50	7·01	7·54	8·10	8·69	9·32	9·99	10·72	31
32	5·47	5·93	6·42	6·93	7·47	8·03	8·63	9·26	9·93	10·65	11·42	32
33	5·81	6·31	6·83	7 37	7·94	8·54	9·18	9·85	10·56	11·32	12·14	33
34	6·17	6·69	7·25	7·82	8·43	9·07	9·74	10·45	11·21	12·02	12·89	34
35	6 53	7·09	7·68	8 29	8·93	9·61	10·32	11·08	11·88	12·74	13·66	35
36	6·91	7·51	8·12	8·77	9·45	10·16	10·92	11·72	12·57	13·47	14·45	36

Equivalents of Lineal Measures.

Inches.	Links.	Feet.	Varas.	Yards.	Chains.	Miles.	Sp. Lea.	En. Lea.
1	0·126263	0·083333	0·029365	0·027778	0·001263	0·000016	0·000006	0·000005
7·92	1	0·66	0·237325	0·22	0·01	0·000125	0·000047	0·000042
12	1·515152	1	0·359583	0·333333	0·015152	0·000189	0·000072	0 000063
33·372	4.213636	2·781	1	0·927	0·042136	0·000527	0·0002	0·000176
36	4·545455	3	1·078749	1	0·045455	0·000568	0·000216	0·000189
792	100	66	23·73247	22	1	0·0125	0·004746	0·004167
63360	8000	5280	1898·598	1760	80	1	0·379720	0·333333
166860	21068·18	13905	5000	4635	210·6818	2·633523	1	0·877841
190080	24000	15840	5695·793	5280	240	3	1·139159	1

Equivalents of Superficial Measures.

Varas.	Yards.	Chains.	Acres.	Miles.	Sp. League	Eng. Lea.
1	0·859329	0·00177547	0·00017755	0·00000028	0·00000004	0·00000003
1·16369865	1	0·00206612	0·00020661	0·00000032	0·00000005	0·00000004
563·230148	484	1	0·1	0·00015625	0·00002253	0 00001736
5632·30148	4840	10	1	0·0015625	0·00022533	0·00017361
3604672·95	3097600	6400	640	1	0·14418692	0·11111111
25000000	21483225	44386·8285	4439·68285	6·93544195	1	0·77060466
32442056·5	27878400	57600	5760	9	1·29768226	1

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WM. SCHMOLZ,

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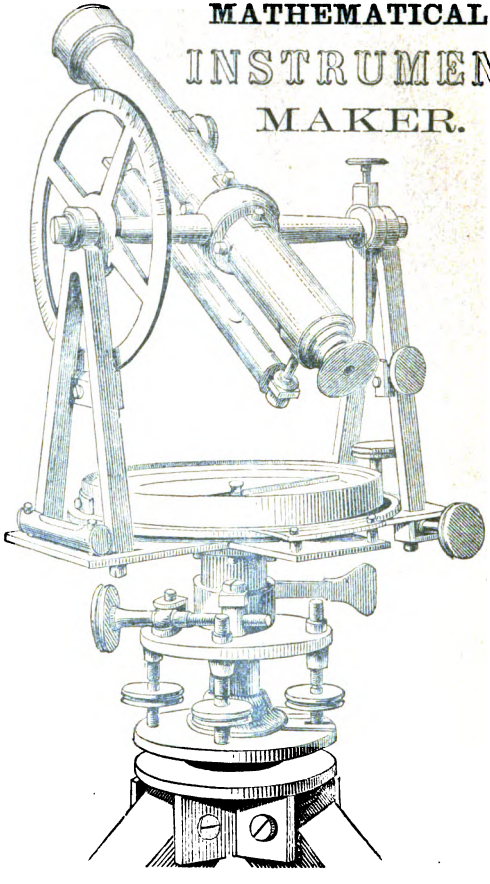

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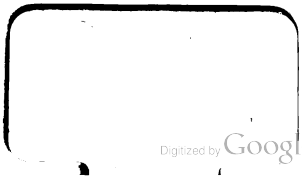
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